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A Destructive Wind-Storm in Cleveland, Ohio.

By GEORGE H. TINKER.*

On April 21, 1909, a wind blowing 66 mi. per hr. did a large amount of damage in Cleveland, O. Eight persons were killed and 80 to 100 more or less severely injured; many buildings were wrecked, the property damage probably amounting to $500,000 or more.

The storm, in its intensity, was local, and appeared to be caused by the meeting of two storms. After a mild thunderstorm and a windstorm lasting through the forenoon, during which the wind velocity rose to 43 mi. per hr., the wind dropped to 20 mi. per hr.; then at 12.33 p. m. it suddenly rose to a 66-mile hurricane. This continued for five minutes, during which time all the damage was done. The small loss of life is due in part to the fact that many buildings which suffered severely, such as school houses and factories, were unoccupied at the noon hour.

The direction of the wind was from southwest to northeast, and to this fact and one other is due the slight damage to the shipping and the waterfront. The other circumstance is that the path of greatest damage, which is narrow, and on an almost straight line through the southern and eastern parts of the city, reaches the lake far to the east of the harbor. This strip of greatest destruction is only 500 or 600 yds. wide, although the limits of damage will cover the entire city and some notable wrecks occurred miles to one side or the other of this path.

Not all the buildings along the path indicated were damaged. The wind seemed to rebound from contact with the earth and, after passing over several blocks with slight damage or none, drop down and again destroy. The storm was apparently of the nature of a tornado. An eye witness not in the path of the storm reports that the clouds seemed to be revolving. Houses were wrenched from their foundations, and the roofs lifted and dropped back, in some cases crushing and overthrowing the supporting walls (see Fig. 1, this page, and Fig. 4, next page). The third-story walls of the National Safe & Lock Co. building (Fig. 2) blew out on two opposite sides, as if from internal pressure. This is characteristic of tornados.

Six ore-unloading bridges were blown down. At the Wellman-Seaver-Morgan works the runway of an overhead crane was so distorted that the crane could not be used. Wires and poles were wrecked, blocking the streets and tying up about half the street car lines in the city.

Some thirty churches were damaged. High brick steeples were blown down and broke through the roofs. Many school houses were partly unroofed or damaged by falling chimneys. Giant trees were uprooted and many monuments in the Woodland cemetery wrecked. The East 55th St. bridge crossing Kingsbury Run and

Fig. 1. Salvation Army Barracks and Kinsman Ice Cream Co. Roof Lifted and Dropped. Walls Thrown Down.

Fig. 2. National Safe & Lock Co. Opposite Walls Blown Out

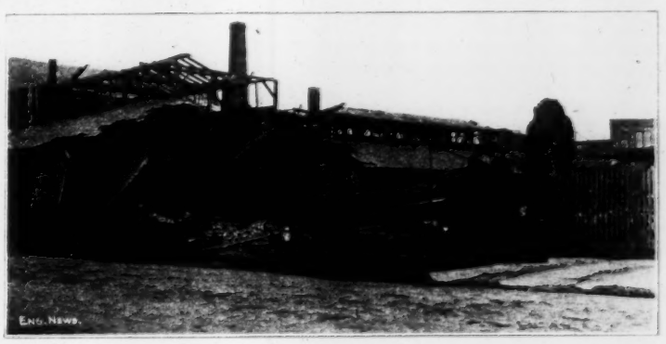


Fig. 3. Cleveland Cooperative Stove Co. Part of Brick-Wall and Timber-Roof Shop Building Wrecked.

BUILDINGS DAMAGED BY TORNADO-LIKE STORM AT CLEVELAND, O., APRIL 21, 1909.

*Bridge Engineer, New York, Chicago & St. Louis Ry., Cleveland, Ohio.

standing nearly at right angles to the direction of the wind was the scene of many personal injuries. Pedestrians were pinned against the railing and wagons overturned. Fortunately the railing did not give way and the most serious injury consisted of broken bones.

The heaviest single loser is probably the Leisy Brewing Co., their damage being $100,000. Other manufacturing plants suffering heavy loss are the Wellman-Seaver-Morgan Co., Standard Tool Co., National Safe & Lock Co., Cleveland Co-operative Stove Co., Kinsman Ice Cream Co., Cleveland Frog & Crossing Co., Cleveland Furnace Co., Erie Railroad, Baltimore & Ohio Railroad and others. Many dwelling houses in the path of greatest destruction are totally wrecked, the salvage being mostly kindling wood.

FIG. 4. A FRAME DWELLING-HOUSE RACKED AND ROOF CRUSHED, IN CLEVELAND STORM.

Statistics of Traffic Across the Central American Isthmus.*

Traffic between the eastern and western coasts of the United States by way of Isthmus railways and steamship lines amounted to practically 50 million dollars in value in 1908, a marked increase over any earlier year.

Two railway lines now carry freights across the narrow neck of land connecting North and South America. One of these railways, that of Panama, is 40 miles in length; the other, at Tehuantepec, 190 miles. The one at Panama, owned by the Government, is, of course, largely devoted to work and traffic growing out of the construction of the Panama Canal; the one at Tehuantepec, 190 miles in length, constructed chiefly with British capital and controlled in part at least by the Mexican Government, is built especially for the purpose of handling freights between the Atlantic and Pacific, and, although opened only at the beginning of 1907, carried during 1907 and 1908 between 60 and 70 million dollars' worth of merchandise passing between the Atlantic and Pacific ports of the United States.

Of the merchandise crossing by way of the Panama Railway, 8½ million dollars' worth moved from the Atlantic to the Pacific, and only a little over 1 million dollars' worth from the Pacific to the Atlantic. Of the 8½ millions crossing from the Atlantic side to the Pacific coast by the Panama line, 2¾ millions was destined to the western ports of the United States, and 5¾ millions to foreign countries located upon the Pacific coast of North and South America, a little over 1 million dollars' worth going to Ecuador; nearly 1 million to Peru; nearly a million to Salvador; three-fourths million to Panama; nearly one-half million each to Honduras and Nicaragua; one-third million each to Colombia and the western coast of Mexico. Of the 2¾ millions from the eastern to the western coast by way of Panama, practically all originated at New York and nearly all was sent to San Francisco. The eastbound merchandise passing through Panama amounted to a little more than 1 million dollars and was shipped exclusively from San Francisco, all of it to New York City.

*From a Bulletin of the Department of Commerce and Labor.

The business of the Tehuantepec line, although much larger in its value than that of the Panama route, was confined almost exclusively to business between the eastern and western ports of the United States, including, however, in this term the Hawaiian Islands, which are now a customs district of the United States. Of the 21 million dollars' worth of merchandise received at the Pacific terminus of the Tehuantepec road and moved eastwardly, 17¾ million dollars' worth was from Hawaii, being almost exclusively sugar.

New York and San Francisco are the chief centers for this ocean and trans-Isthmian traffic between the eastern and western coasts of the United States. Of the 2¾ million dollars' worth of domestic traffic passing westwardly over the Panama line, practically all originated at New York and 2½ million dollars' worth of it went to San Francisco. Of the 5¾ million dollars' worth destined for foreign countries on the Pacific frontage of North, Central and South America practically all originated at New York. Of the 16½ million dollars' worth passing westwardly over the Tehuantepec line practically all originated at New York. Of the 17¼ million dollars' worth of sugar from Hawaii crossing the Tehuantepec line for the Atlantic front, practically all went to the refineries of Philadelphia and New York, chiefly the latter. Of the nearly 3½ million dollars' worth of miscellaneous merchandise passing over the western coast ports to those of the east by way of the Tehuantepec line, 3 million dollars' worth originated at San Francisco and about 3 million dollars' worth was destined for New York.

The distances between New York and San Francisco by the two lines are, via Panama, 5,305 miles; via Tehuantepec, 4,415 miles; direct by shortest transcontinental railway line, 3,191 miles, and by way of Magellan Straits, 13,089 miles. From the Hawaiian Islands to New York the distances are, by way of San Francisco, 5,288 miles; by way of Tehuantepec, 5,806 miles; by way of Panama, 6,686 miles, and by way of Magellan Straits, 13,269 miles.

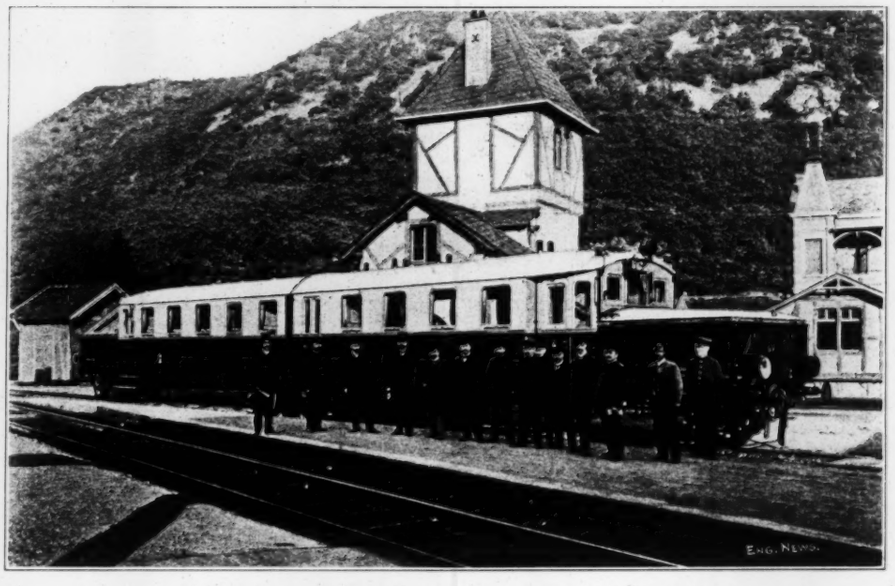
Storage-Battery Railway Cars: Prussian State Railways.

By J. B. VAN BRUSSEL.*

Storage-battery motor cars were put into service on the Prussian State Railways some 18 months ago, as noted in Engineering News, Aug. 22, 1907. The result of the first year of operation was so satisfactory that 57 double-unit cars, of an entirely new pattern, were ordered. These cars are for use in supplementing the heavy express service by connecting outlying districts with stations at which express trains stop, for suburban service and where the traffic is not sufficient to warrant steam service.

The new double units, shown in the accompanying figure, consist of two four-wheeled cars coupled together. Each half unit carries its storage battery in a shallow compartment, like an automobile hood, projecting beyond the driver's cabin. This disposition of the cells has been found preferable to that on the earlier type of car, where the cells are placed under the seats. It was found impossible to prevent some damage to the car fittings and discomfort to the passengers by the fumes from the acid. Each of the new double cars can carry 100 persons, some standing. Entrance to each half is through the driver's cabin.

Each half unit carries a single interpole series motor rated at 50 HP. on a ten-hour basis and at 80 HP. for two hours. The control is series parallel, from either half unit, for both motors. The battery consists of 168 cells, 84 in each hood. The groups are connected in series so that the minimum motor voltage is 310. The battery has a capacity of 368 ampere-hours, allowing a minimum running distance of 100 kilometers (62 miles) on one charge. A maximum speed of 50 kilometers per hour (31 mi. per hr.) can be reached on level track. The cars have air-brakes, for which a single compressor is installed on each double unit. The total weight of the complete motor car is about 55 tons.



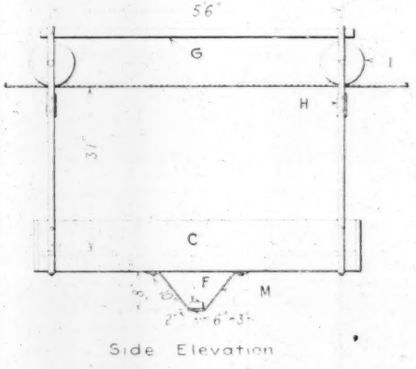
STORAGE BATTERY MOTOR CAR; PRUSSIAN STATE RYS.

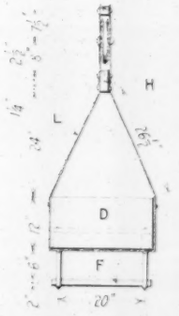
*Boite Postal 151, Brussels, Belgium.

The Design of Cable Stations for River Measurements.

By J. C. STEVENS.*

The Water Resources Branch of the U. S. Geological Survey maintains a large number of river-gaging stations where cables are required. The list of "cable stations" is being continually added to, not only by the government but by power and irrigation companies and by others who wish to maintain continual records of the flow of certain streams. Such a determination of course requires that actual measurements of discharge be made at different stages of the stream. For such a "rating" the current meter has been found to be the cheapest and most effective method. Its use requires facilities for the operator to measure depths and determine velocities at all points in the cross section of the stream. Wherever bridges are found coincident with the requisite conditions they are, of course, utilized, but where they are not available it is necessary to construct a gaging bridge or install a cable station.





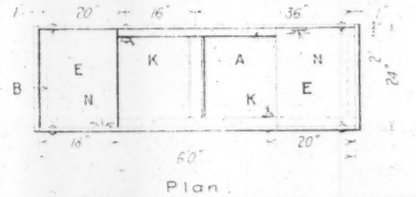


FIG. 1. DETAILS OF CABLE CAR FOR STREAM GAGING STATION, WATER RESOURCES BRANCH, U. S. GEOLOGICAL SURVEY, COLUMBIA RIVER DISTRICT.

No. of pieces.	Materials.	Index letter.
2	2″ × 4″ × 6′ sides of bed frame	A
2	2″ × 4″ × 18″ ends of bed frame	B
2	1″ × 12″ × 6′ sides of bed	C
2	1″ × 12″ × 24″ ends of bed	D
4	1″ × 9″ × 21¾″ seats	E
1	2″ × 4″ × 23″ foot rest	F
1	2″ × 2″ × 6′ (exact) top spacing bar	G
2	2″ × 13¼″ × 5″ (exact) spacing blocks	H
2	10″ × 17¾″ × ⅝″ rope sheave, spoked	I
2	3″ × ¾″ × ⅝″ rope sheave	K
2	1⅜″ × ¼″ × 11′ 10″ steel hangers—bent	L
2	1″ × ¼″ × 30″ steel hangers—bent	M
2	2¾″ × ⅞″ bolts, with coffer pins, for 10″ sheaves	
6	2¾″ × ¼″ bolts for spacing blocks	
4	1½″ × ¼″ bolts for main hanger	
4	5½″ × ⅜″ bolts for main hanger	
4	4½″ × ⅜″ bolts for foot rest hanger	
2	2½″ × ⅜″ bolts for foot rest.	
2	1″ × ⅜″ bolts for small sheaves	
2	Awning rope fasteners with screws	N

The proper design of a cable station involves some of the principles that have been discussed in recent publications concerning catenary trolley construction.† In both instances the sag is small compared with the span, but cable-station design deals with concentrated live loads while only dead loads are considered in the case of catenary trolley construction. As the method of treatment and formulas deduced will be applicable to many other lines of work where cables are used the results of study in this direction will not be out of place.

The equipment for a cable station consists of the towers, a traveling car, the cable, a turnbuckle and the necessary anchorages and cable clamps.

CARS.—The traveling car should be of such design that the operator can work with comparative comfort, and light enough to be easily propelled by hand by pulling on the cable. The open-bottom car has decided advantages over other styles. Fig. 1 shows the standard design adopted in the Columbia River District. Its operation is well shown in Fig. 2.

TOWERS.—From an economical standpoint the towers should be low enough to admit of their construction from single lengths of timber. The simplest and cheapest tower is the A-frame or "shear-legs" made of 4 × 6-in. timbers of the required length, crossed near their top, mortised and bolted together. This construction will answer for towers up to 20 ft. in height. The bottom of the legs should be fastened to a level mud sill by means of lag screws. The cable rests in the forks of the timbers without other bearing than on wood.

DESIGN OF CABLE.—The high-water stage determines the lowest point to which the cable can sag, for, evidently, it must be high enough to admit of measurements being made even in the highest flood, and also to be out of the way of drift when not in use. If the stream is navigable legal requirements will determine the point to which the cable can hang.

The requirements of a minimum sag to admit of easy operation of the car, as well as to render tower construction as cheap as possible, are best fulfilled by the use of plow-steel standing rope with 6 strands of 7 wires each, since this cable combines the lightest weight with the greatest strength and the lowest cost. The galvanized cables are preferable and can be secured at a slight increase in cost over the black cables.

The problem consists of selecting a size of cable to fulfill the required conditions of sag, and of finding the erection sag—i. e., the point to which the cable should be drawn without load so that when loaded the allowable sag and tension will not be exceeded.

Let d = distance between supports or the span
l = length of cable
s = sag of the loaded cable
s_o = sag of the unloaded cable
P = live load
w = weight of cable per foot of length
T = horizontal component of tension in the loaded cable
T_o = horizontal component of tension in unloaded cable
a = area of cross section of cable
E = coefficient of elasticity of cable

Where the ratio of sag to span is small, as in the present case, it is sufficiently accurate to assume horizontal loading of the cable, with the consequent assumption that the cable hangs in a parabolic arc rather than a catenary.

By taking moments at one of the supports (see Fig. 3) we find the following equations:

$$T\,s = \frac{w\,d^2}{8} + \frac{P\,d}{4} \quad \ldots\ldots (1)$$

for the loaded cable, and

$$T_o\,s_o = \frac{w\,d^2}{8} \quad \ldots\ldots (2)$$

for the unloaded cable.

In equation (1) the tension is taken as 1.5 the breaking strain. For any given load, P, tables or diagrams of sags, for stock sizes of cables can be prepared. For the purposes herein discussed the live load is taken as 500 lbs. Table I. gives the sags for stock sizes of plow-steel standing rope with 6 strands of 7 wires each. (American Steel & Wire Co. Catalog.)

The erection sag is found by considering the effect on the cable when the load is removed. When loaded the cable is assumed to hang in two parabolic arcs. When the load is removed the cable assumes the shape of a single parabolic arc which of itself lessens the sag. At the same time the tension is decreased, which shortens the cable, thus tending to still further reduce the sag. But the cable cannot shorten the entire amount represented by the decrease of tension due to removal of the load, for where the sag is small a very slight change in length decreases the sag and increases the tension at a very rapid rate. Thus, we may assume that the sag, s_o, is reached in two steps: (1) the cable reaches some intermediate sags, s, say, due to change in form from two arcs to a single parabolic arc, assuming the length to remain constant; (2) the sag changes from s_1 to s_o, due to change in length of cable.

Let s_1 = intermediate sag due to removal of load, assuming length of cable constant.
T_1 = horizontal component of tension corresponding to s_1.
c = length of the two chords $A\,B + A'\,B$ (See Fig. 3).
s_2 = sag of the cable from the chord $A\,B$ (See Fig. 3).

Evidently

$$s_2 = \frac{w\,d^2}{32\,T} = \frac{s_1\,T_1}{4\,T} \quad \ldots\ldots (3);$$

also $$c = \sqrt{d^2 + 4\,s^2} \quad \ldots\ldots (4).$$

The length of the cable without the load but under the same tension as when loaded would be

$$l = d + \frac{8\,s_1^2}{3\,d} \quad \ldots\ldots (5).$$

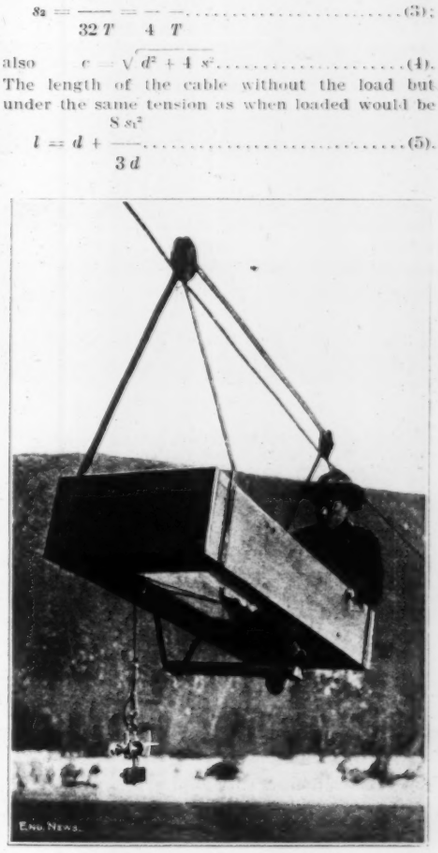


Fig. 2. Cable Car for Gaging Stations, U. S. Geological Survey.

*District Engineer, Water Resources Branch, U. S. Geological Survey, Portland, Ore.
†Eng. News, Oct. 22, 1908. Proc. Am. Soc. C. E., Sept., 1908.

Also the length of the loaded cable which hangs in two arcs is

$$l = c + \frac{8 s_2^2}{3 c} \quad \ldots\ldots (6).$$

Substituting the value of s_2 in equation (3) and calling $\frac{T_1}{T} = r$ for convenience equation (6) becomes

$$l = c + \frac{s_1^2 r^2}{6 c} \quad \ldots\ldots (7).$$

Fig. 3. Diagram Illustrating Computations of Sag in Loaded Cable.

Now equate (7) and (5) and solve for s_1 and we have

$$s_1^2 = \frac{6 c d (c - d)}{\pm 6 c - r^2 d},$$

but $c^2 = d^2 + 4 s^2$ ..... (4)

whence $c - d = \frac{4 s^2}{c + d} = \frac{2 s^2}{d}$ (approximately).

We may place $c = d$ where their products are taken and also call them equal in the denominator of the above expression without appreciable error, hence we find

$$s_1 = s \sqrt{\frac{12}{16 - r^2}} \quad \ldots\ldots (8)$$

For $r = 0$ in this expression $s_1 = .87\,s$ and for $r = 1$, $s_1 = .89\,s$. In fact s_1 may be taken as $.87\,s$ without more than 3% error in all cases of this kind. This is equivalent to saying that the loaded cable hangs in two chords instead of two arcs. The error is greatest for light loads on heavy cables.

For practical purposes it is sufficient to say therefore

$$s_1 = 0.87\,s \quad \ldots\ldots (9).$$

Equation (9) states that the sag of the cable without the load is 7/8 of the sag with the load, provided the length of the cable remains constant.

The next step is that of finding the further reduction in the sag from the shortening of the cable by reason of the decrease in tension due to removal of load. The cable comes to rest at a sag of s_0 and a corresponding tension T_0, unknown but somewhat greater than T_1. (See Fig. 3.)

The shortening of the cable is

$$\triangle l = \frac{(T - T_0)\,d}{a\,E} \quad \ldots\ldots (10).$$

Now let v = the increment in sag due to $\triangle l$ and we have

$$l - \triangle l = d + \frac{8 (s_1 - v)^2}{3 d},$$

or by subtracting (5),

$$\triangle l = \frac{8 (2 s_1 v - v^2)}{3 d} \quad \ldots\ldots (11).$$

Equating (10) and (11),

$$(s_1 - v)^2 = \frac{3 d^2}{8 a E} (T - T_0) + s_1^2;$$

but $(s_1 - v)$ is the net sag or s_0, hence

$$s_0 = \sqrt{s^2 - \frac{3 d^2}{8 a E} (T - T_0)} \quad \ldots\ldots (12).$$

An examination of the tables for plow-steel standing rope will reveal the following very approximate relations.

$T = 22{,}000$ lbs. per sq. in. of cross-section.

$w = 2$ lbs. per sq. in. of cross-section.

Hence,

$T = 11{,}000\,w$,

and

$$a = \frac{w}{2}.$$

Taking $E = 22{,}000{,}000$ (see Eng. News, Oct. 22, 1908) and substituting the above values, and equations (2) and (9) in equation (12), it reduces to

$$s_0^3 + (.000375\,d^2 + .75\,s^2) s_0 = .000{,}000{,}004{,}25 d^4 \quad \ldots\ldots (13).$$

The value of s is taken from Table I. and for any given span and cable (13) reduces to simpler form. Thus for a 5/8-in. cable and 300-ft. span it becomes

$$s_0^3 + .35\,s_0 = 36.1,$$

which can readily be solved by trial giving

$$s_0 = 3.25 \text{ ft.}$$

The value of s with the load of 500 lbs. was 6.55 ft.

Table II. has been prepared by the solution of equation (13) giving the erection sags for the cables and spans given in Table I., together with the tensions corresponding to s_0, in order that the strength of hoisting tackle may be known. The values in both tables are shown diagrammatically in Fig. 4.

ERECTION OF CABLES.—The erection of cable stations frequently calls for some ingenuity on the part of the engineer. One of the most efficient hoisting devices is the ordinary differential chain block. Where such a block is not available the turnbuckle can be used with good advantage, but the repeated fastenings require considerable time. By the following very simple method two men with a small four-ply block and tackle can erect a cable of 500 to 600 ft. in span: Make the cable permanently fast at one of the anchorages. Raise the support on the same side of the stream and brace it in position with the cable in place. Then from the other side of the stream draw the cable as tight as possible with the small block and tackle and fasten it temporarily through one eye of the turnbuckle, the other eye being fastened to the anchorage. Now lay the "shear leg" on the ground underneath the cable with the fork which is to carry the cable pointing toward the river and in such a position that when that end is raised, the support will be in position and the cable will fall into place and be raised with it. The support can now be raised with the block and tackle by pulling over an auxiliary pair of lightly constructed "shear-legs." As the support rises the cable will be raised and tightened. The cable is then adjusted to the proper sag by means of the turnbuckle.

The laying of the cable across the stream is frequently a perplexing problem, especially where the stream is too swift for a boat or where one is not available. One method the writer has used with good success utilized the principle of the ferryboat. Stretch ordinary telephone wire of a length at least three times the width of the stream, along one bank at the water's edge, and up-stream from the cable site. The upper end is fastened or held by an assistant while the lower end is fastened to a 2-in. by 6-in. timber, 14 or 16 ft. long. The timber is fastened with a yoke to the wire so as to float at a decided angle to the current. Another wire long enough to reach well across the stream is fastened to the timber at the cable site, the timber is set afloat and the wire played out as the timber travels across the stream, swinging in an arc around the point where the long wire is held or fastened. With a line across the stream the rest is easy.

TABLE II.—ERECTION SAG IN FEET FOR CABLES.

(Plow-steel standing rope, 6 strands of 7 wires each for concentrated live load of 500 lbs.)

Span,	Diameter of Cable, ins. 1/2		9/16		5/8		11/16		3/4		7/8		1	
ft.	Sag.	Tension.	Sag.	Tension.	Sag.	Tension.	Sag.	Tension.	Sag.	Tension.	Sag.	Tension.	Sag.	Tension.
100	1.76	280	0.80	780	0.41	1,900	0.24	3,900	0.19	5,800	0.15	10,000	0.13	15,200
200	3.89	500	2.40	1,080	1.53	2,000	1.05	3,600	0.79	5,000	0.62	9,700	0.53	14,900
300	6.35	690	4.40	1,280	3.14	2,200	2.35	3,600	1.88	5,300	1.47	9,200	1.26	14,100
400	9.05	850	6.60	1,500	5.02	2,400	3.85	3,500	3.16	5,600	2.60	9,200	2.27	13,900
500	12.06	1,000	9.15	1,700	7.26	2,760	6.00	3,500	5.05	5,500	4.12	9,100	3.62	13,600
600	15.40	1,140	12.3	1,800	9.80	2,800	8.10	4,200	7.10	5,600	5.95	9,100	5.20	13,600
800	22.60	1,380	18.8	2,100	15.4	3,200	13.5	4,400	12.0	5,900	10.3	9,300	9.20	13,700
1,000	30.70	1,580	25.6	2,400	22.1	3,500	19.7	4,700	17.9	6,200	15.7	9,500	14.2	13,800

TABLE I.—SAGS IN FEET FOR LOADED CABLES.

(Plow-steel standing rope 6 strands, of 7 wires each, for concentrated live load of 500 lbs.

Span,	Diameter of Cable, ins. 1/2	9/16	5/8	11/16	3/4	7/8	1
ft.	Tension of Cable in lbs. 4,400	5,600	6,800	8,400	9,600	12,800	16,800
100	2.95	2.34	1.95	1.60	1.42	1.10	0.86
200	6.13	4.90	4.12	3.42	3.04	2.42	1.95
300	9.50	7.61	6.55	5.47	4.94	3.99	3.28
400	13.12	10.69	9.19	7.74	6.87	5.78	4.83
500	16.97	14.00	12.05	10.25	9.40	7.82	6.62
600	21.05	17.44	15.15	13.00	11.97	10.10	8.66
800	29.80	25.00	22.00	19.10	17.80	15.30	13.40
1,000	39.5	33.5	29.8	26.1	24.6	21.5	19.1
2,000	101.3	89.3	82.2	74.5	71.8	66.4	61.6

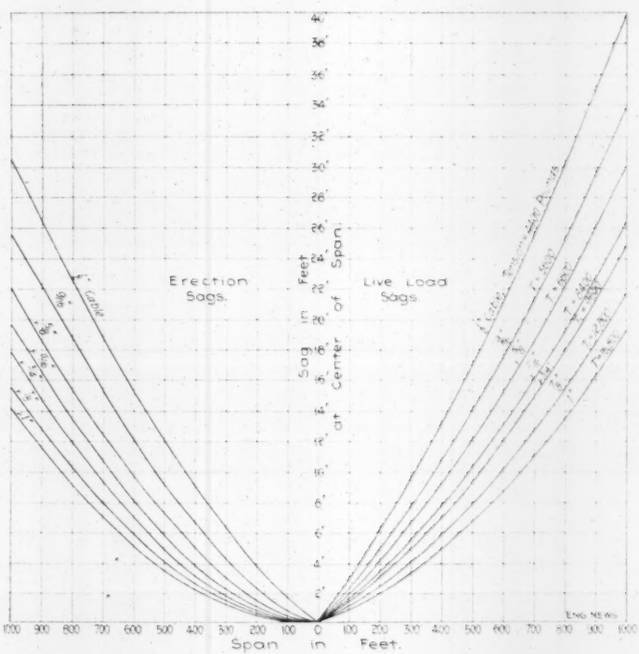


FIG. 4. DIAGRAMS FOR DESIGN OF CABLES FOR STREAM GAGING STATION, U. S. GEOLOGICAL SURVEY.

(For plow-steel standing rope, 6 strands of 7 wires each, designed for concentrated load of 500 lbs. per sq. in. at center of span.)

BRILL MEMORIAL MEDAL AND PRIZE.—In the fall of 1908 The J. G. Brill Co., of Philadelphia, published an offer, to senior students in the technical schools of the United States, of three prizes of $250, $150 and $100, for essays on the subject "Design of an Electric-Railway Car for City Service." In view of the interest shown by the students and by the electric-railway men, the president of the Brill company has announced that the first prize will be accompanied by a gold medal in memory of John A. Brill, former Vice-President of the company. It is the intention of the Brill company to offer annually these prizes for essays of merit on subjects connected with electric-railway work.

The Improvement of the Upper Mississippi River.*

By C. McD. TOWNSEND, M. Am. Soc. C. E.†

The works constructed in the upper Mississippi River afford excellent illustrations of the successful solution of many of the problems that arise in the improvement of non-tidal rivers. The obstacles at the Des Moines Rapids have been surmounted by a lateral canal. At the Rock Island Rapids a channel has been excavated through the rock composing the bed of the river and the slopes modified by submerged dams and wing dams, as effectively as in the celebrated improvement of the Iron Gate on the Danube. The stretch of river from St. Paul to Lake Pepin is an example of as successful a regulation of a river by wing dams and bank revetments as can be found on any river in Europe. Levees have been constructed which protect from overflow 220,000 acres of alluvial bottom lands, and harbors of refuge from ice and storms have been built.

As the river and harbor act of 1907 enlarged the project for improving this portion of the river, the close of the fiscal year ending June 30, 1906, becomes a suitable time to sum up the work done under the original project.

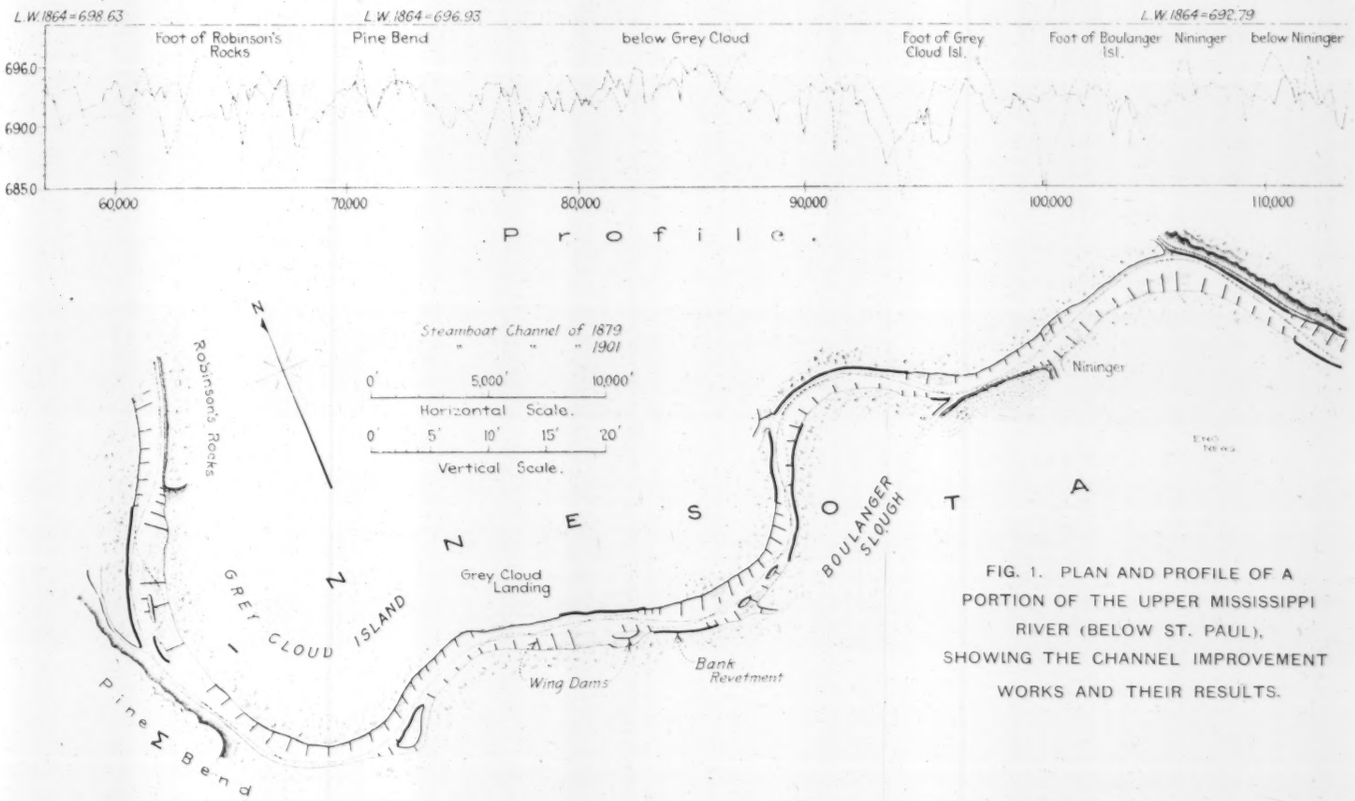


FIG. 1. PLAN AND PROFILE OF A PORTION OF THE UPPER MISSISSIPPI RIVER (BELOW ST. PAUL), SHOWING THE CHANNEL IMPROVEMENT WORKS AND THEIR RESULTS.

The work on the upper Mississippi River described in this paper extends from the Omaha bridge at St. Paul, Minn., to the mouth of the Missouri River, a distance of about 658 miles. At St. Paul the river drains an area of about 32,000 sq. miles and has an extreme low water discharge during the season of navigation of about 2,000 cu. ft. per sec. The extreme flood height recorded, that of 1850, is 19.7 ft. above datum (the low water of 1864) and 20 ft. above the low water of 1894, the lowest recorded stage that has occurred when the river was not frozen over. The discharge of the river has been measured at a gage height of 17.5 ft. and found to be about 85,000 cu. ft. per sec.

The valley of the upper Mississippi is narrow. The hills have in general steep slopes on the river side, so that the minor streams when in flood bring into the river large quantities of gravel and in some instances boulders of considerable size, which it is occasionally necessary to remove by dredging.

When the main channel of the river washes the hills on one side of the valley, there is usually found on the other side a minor channel termed a slough, connecting with the main channel by numerous cross sloughs. At low stages many of these sloughs are dry, but at medium or flood stages the alluvial valley contains numerous islands through which the main channel of the river winds, but loses considerable of its energy by the draft into the side channels. In its unimproved condition bars frequently formed in the channel having depths on their crests of less than 1½ ft. below low water. The channel was also obstructed by snags, boulders and ridges of rock extending across the river. The most noted of these rock ridges form the Rock Island rapids and Des Moines rapids.

Due to the limited appropriations by Congress and the irregularity with which they have been made, the systematic method of improvement adopted on many foreign rivers could not be applied to the upper Mississippi. It has been necessary to distribute the funds available over the entire district, first improving those bars having the least depth of water on them, and when these have disappeared, regulating the next shoalest bars. This process has been continued until at the present time bars restricting the channel to depths of less than 3½ ft. are seldom found.

When a partial improvement of the river is attempted, and the channel contracted over a single bar, there is usually a large movement of sand, which has a tendency to be deposited in the first wide portion of the river below, and which may form an obstruction as serious to navigation as the bar removed. This has been particularly true of the shoal river between St. Paul and Prescott, where it has been necessary to contract the river to a uniform width of 400 ft. for the entire distance.

Fig. 1 is a portion of a map of the river from St. Paul to Prescott (27.9 miles), with profiles of thalweg depths derived from surveys in 1879 and 1901, when the work was completed. The theoretical least depths on bars, measured from the low water of 1864, has increased from 1 ft. to 4.3 ft. From Prescott to Lake Pepin (26 miles), the river has been improved in a similar manner, and the least depth on bars at low water has been increased from 1.8 ft. to 4.7 ft. Due to the gentle slope and the resultant gentle current on this portion of the river, a uniform contraction of the channel to the width of 600 ft. prescribed by the original project has not as yet become necessary.

Above St. Paul, navigation is impeded by the Falls of St. Anthony and the rapids below them; and the river empties into Lake Pepin a practically level body of water. The portion of the Mississippi River between St. Paul and Lake Pepin may be considered therefore as an independent stream whose improvement has been completed in accordance with the original project. Attention is invited to the fact that this improvement has been accomplished without that dangerous disturbance of the original slopes of the river, which has been observed in attempts to regulate numerous European streams.

Below Lake Pepin while there are long stretches of channel that have been similarly improved, there are interspersed portions of the river where no work has been done. In those portions of the river where the channel has been contracted, as satisfactory results have been obtained as in the river above. But in the unimproved portions new bars have frequently formed, or the original bars shoaled, so that the practical results of the expenditures thus far made have increased the navigable depth of the 650 miles of river under improvement from 1½ ft. at extreme low water to 3 ft.

The cost of the work in the river, divided into sections, is shown in the accompanying table.

General Improvement of the River Channel.

The original project for the improvement of the upper Mississippi was adopted in 1878, and proposed the contraction of the waterway by the closure of chutes, construction of wing dams, and revetment of caving banks, so as to obtain a navigable channel of a depth of 4½ ft. at extreme low water, to be eventually increased to 6 ft. The datum adopted is the extreme low water of 1864. At the various gages this varies from 1.25 ft. to 2 ft. below the plane of the mean of low water during the seasons of navigation; but when the river is frozen over, gage readings below zero are not infrequent.

The width to which the river is being contracted is 400 ft. from St. Paul to the mouth of the St. Croix River (mile 30); 600 ft. from the mouth of the St Croix to Lake Pepin (mile 56); 800 ft. from Lake Pepin to the mouth of the Wisconsin River; thence to Rock Island

TABLE OF NET EXPENDITURES ON VARIOUS SECTIONS OF THE UPPER MISSISSIPPI RIVER FOR HARBORS, LEVEES, ETC., BETWEEN MINNEAPOLIS AND THE MISSOURI RIVER (FROM COMMENCEMENT OF IMPROVEMENT TO JUNE 30, 1906.)

Locality.	Distance, miles.	Cost— Total	Cost— Per mile.
St. Paul to Minneapolis	..	$59,113	....
St. Paul to Prescott	30	671,798	$22,393
Prescott to Lake Pepin	26	338,219	13,008
Foot of Lake Pepin to Alma	11	467,503	42,500
Alma to Winona Bridge (C. & N. W. Ry.)	28	790,102	28,218
Winona Bridge to La Crosse Bridge (C., M. & St. P. Ry.)	28	805,780	28,778
La Cross Bridge to McGregor Bridge	64	667,672	10,437
McGregor Bridge to Dubuque Bridge (Ill. C. Ry.)	57	489,795	8,242
Dubuque Bridge to Clinton Bridge (C. & N. W. Ry.)	62	451,810	8,900
Clinton Bridge to Le Claire	21	39,830	1,897
Rock Island Rapids	14	609,994	....
Rock Island Bridge to Keithsburg Bridge	55	377,859	6,870
Keithsburg Bridge to Nashville	59	934,077	15,832
Keokuk Bridge to Quincy Bridge	37	604,700	16,343
Quincy Bridge to Clarksville	56	1,086,951	19,410
Clarksville to Cap au Gris	37	915,190	24,375
Cap au Gris to Illinois River	24	441,582	18,399
Illinois River to Missouri River	23	440,659	14,800
Total		$10,252,653	....

*Abstract of a paper read before the Western Society of Engineers (Chicago) on Nov. 4. The paper is lengthy and comprehensive, dealing very fully with the characteristics of the upper Mississippi at various points of its course, and with the history of the improvement works. Our abstract, however, relates mainly to the character and construction of the improvements.—Ed.

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rapids (mile 318), 1,000 ft.; from Rock Island to Quincy (mile 521), 1200 ft.; from Quincy to Louisiana (mile 567) 1300 ft.; from Louisiana to the mouth of the Illinois River (mile 631) 1400 ft.; and from the Illinois River to the Missouri 1600 ft.

The works of improvement consisting of bank revetment, wing dams, closing dams and longitudinal dikes, are generally constructed of brush and rock.

BANK REVETMENT.—This consists (below the water surface at the time of construction) of a mattress of brush fascines sunk in place by rip-rap rock; above low water line, it consists of riprap of 6 to 12 ins. of rock. The width of brush mattresses varies from 20 to 60 ft., being affected by the stage of the river at time of construction, and the depth of water. The fascines are preferably made of willow brush, which is found in large quantities on the islands and sand bars in the river. Where there is a local scarcity of willows, the use of other varieties of wood sufficiently straight to be bound into fascines has been allowed. Recent specifications require that fascines shall be made of live brush sufficiently trimmed and choked to form a compact mass 20 ft. long and from 12 to 15 ins. diameter, tied with bands of lath yarn or wire not more than 4 ft. apart. When made into mats they are closely packed and secured at distances of 8 to 12 ft. by pairs of binding poles joined by ties of lath yarn or wire about 2 ft. apart. The fascines are laid with their butts pointed down stream. The early practice was to lay them at right angles to the shore line, butts to the bank, but in this position on steep banks there was found a tendency of the stone covering to slip.

The mattresses are constructed on small flat boats having inclined ways upon them, which are locally known as "grasshoppers." The hull is about 2 ft. deep, 14 to 22 ft. wide, and 32 to 40 ft. long. On this are placed ways or skids running fore and aft, usually four or five pieces of scantling rounded and smoothed on the upper side. They are given an angle of about 30° with the water surface, to facilitate launching the mat, and extend over the forward end nearly to the water surface.

When a length of mat equal to the length of the ways has been constructed, the boat is dropped down the river a distance of about 20 ft., a corresponding length of the mattress sliding into the water. Another row of fascines is then added, lapping the preceding row by from 4 ft. to 10 ft. In this manner a continuous mattress is constructed along the bank to be protected. It has been found advisable to employ small binding poles, to give greater flexibility to the mat. In some portions of the river three or four good-sized willow brush are substituted for the binding pole, with advantageous results. The necessity of flexibility in the mat is not only to prevent rupture while sinking, but it is found that as soon as the mat is in place the river currents produce a scour at the toe of the mat. Unless it is sufficiently flexible to conform to this scour, it is undermined and slips farther into the river, producing a break in the revetment at the water surface.

The upper bank is graded to a slope of from 1 on 1½ to 1 on 3 before the riprap is placed. In the upper portions of the river, where the banks are low, the work is done by manual labor. In the vicinity of the mouth of the Missouri, where the banks are higher and more sandy, economic results have been obtained by the use of a drag scraper operated by the steam engine on a pile-driver. It has been the practice on certain portions of the river to sink the mattress one season and allow the river itself to grade the upper bank during the next flood, and complete the work another season. This method of procedure is economical, provided the completion of the work be not too long delayed.

WING DAMS.—These are constructed for the purpose of contracting the width of the river at low stages (see Fig. 2). It was originally proposed to construct the dams in accordance with the practice of German rivers, giving them an inclination of 105° to 110° up stream in straight reaches, 100° to 102½° on concave banks, and 90° to 100° on convex banks; so locating them that their axes intersect in the middle of the channel. They were to be spaced at 5/7 of channel width in straight reaches, half the channel width on concave banks, and on convex banks the width of the channel. While in general this plan has been adopted, there have been numerous exceptions, particularly in the spacing of the dams, due principally to economic considerations. The heights to which the dams have been constructed are also variable. The present practice is to build them to a grade 4 ft. above low water on the upper portion of the river and 6 ft. above low water below the Des Moines rapids.

In their construction a mattress containing a single layer of brush fascines, bound with three sets of binding poles, is first sunk the entire length of the dam, to prevent scour during the process of construction and to serve as an apron to receive the flow over the dam. This is covered with a layer of riprap rock about 6 ins. thick on the upper side and 12 to 18 ins. on the lower side. A second mat is sunk on this riprap from 10 to 15 ft. further up stream and covered with stone. Additional mats are similarly placed and covered until the required grade is attained, each mat being placed 2 ft. further up stream than the one immediately below it. In filling deep holes, the use of multiple mats is permitted; that is, mats composed of several layers of fascines. To prevent the erosion of the bank, it is revetted 25 to 50 ft. above and about 50 to 75 ft. below the point where the dam abuts against it.

In dam construction a "building boat" is held in position by lines extending to anchors, anchor mats, or piles, previously put in position, and a barge of brush placed along its upper side. A barge of stone is held about 20 ft. below by lines extending to it, and between the building boat and rock barge is placed the "grasshopper" on which the mat is constructed.

The mats for dams are constructed with the fascines laid across the "grasshopper," butts down stream. They are usually bound with three sets of binding poles securely tied with lath yarn or wire, usually at every third fascine. The length of the mat varies with the swiftness of the current and depth of water, but rarely exceeds 100 ft. Lines are attached to the binding poles over the tips about 10 ft. apart, and to the binding poles over the butts about 20 ft. After the mat is launched, these lines are fastened on the building boat.

Care is required in sinking the mat to prevent the river currents from turning it over and dumping the load of rock. An excess of rock is placed on the upstream side of the mat, and the lines connecting it to the building boat are gradually eased off. In shoal water the upstream edge of the mat is sunk to the bed of the river before the lines running from the butts to the building barge are loosened. After the mat is sunk, the rock is uniformly distributed over it, and the lines used in sinking it are then removed, having been originally attached with a turn to facilitate their removal.

On the lower sections of the river the mat is constructed from tilting ways on the building boat, instead of from a "grasshopper." The boat is 165 × 26 × 4 ft., and is equipped with two steam capstans and a set of 100-ft. tilting ways. There are also hand capstans for handling by hand (if necessary) the anchor lines and the lines extending to the stone barge.

The tilting ways are made of 18-ft. oak timbers, 4 × 5 ins. These are set on edge about 8 ft. apart and securely fastened together by a fore and aft stringer on the inboard side. At 4 ft. from their outer ends they are set in a block 1 ft. high, to which they are joined by a heavy strap hinge. To each alternate way is attached a pine timber, 4 × 4 ins., that extends down through a hole in the deck to near the bottom of the boat, when the ways are horizontal. A wire rope runs from the lower end of each of these timbers to a pulley on the deck above it, and is joined to a wire rope extending along the back of the ways to a pair of triple blocks, which are connected with the drum of one of the steam capstans. After the mat has been constructed, by winding on this capstan the inboard ends of the ways are raised and the mat is launched.

CLOSING DAMS.—These are employed to close chutes and side channels. They are constructed similarly to wing dams, but usually contain more rock, and the bank revetment extends a greater distance both above and below them. In long chutes, at low stages, a head of water exceeding 4 ft. may exist on the dam. In such cases breaks have been not infrequent, and the experiment has recently been made of multiplying the number of dams in the chute so as to diminish the head on each and to increase the tendency to deposit sediment in the chute.

LONGITUDINAL DIKES.—These are similar in construction to wing dams, but, as their name indicates, instead of being built approximately at right angles to the current, they extend approximately parallel to it.

PILE AND BRUSH DAMS.—During the first years of the improvement, pile and brush dams were built quite extensively above Hastings (mile 27). In constructing these dams, an apron was laid in the usual manner and piles were driven through it on the line of the dam. The distance between piles was about 4 ft. They were connected by a stringer at about 3 ft. above low water. Against this stringer, brush fascines were laid side by side, with their tips up stream and their butts extending 1 ft. over the stringer and bound to it with binding poles and wire. A small amount of rock was then thrown on the tips. Due to the small quantity of sediment in the upper river, these dams have not been as successful as similar ones in the river below St. Louis. They were cheaply constructed, but after a few years they became so dilapidated that it was necessary to convert them into ordinary brush and rock dams.

Where it has been necessary to dredge through gravel bars, the material removed has been frequently employed as a foundation for dams and topped with regular courses of brush and rock. The ferry dike opposite Hannibal (mile 540) was built entirely of gravel, dumped at a 7-ft. stage, and has required no repairs since its construction in 1883. A number of sand dams have been built above Lake Pepin with an hydraulic dredge, which deposits the body of the dam in such a shape that a single course of brush and rock completes it. Their cost is about half that of the ordinary brush and rock dam. They have usually been put in as intermediate dams of a series, and in such a location appear to be as durable as the ordinary type.

The proportion of stone to brush employed in constructing the different works has varied. The present practice is: for bank revetment, about 1 to 1; for closing dams, 1 of rock to 1½ of brush; for wing dams, 1 of rock to 2 of brush. A number of dams have been constructed with the ratio of 1 to 4. The repairs to these dams have been greater than to those containing a larger percentage of rock.

The only marked exception to the methods of work is on the section of the river above Alton, where longitudinal dikes have been constructed similar to those on the Rhone River, (described by M. H. Girardon in a paper on the Regulation of Rivers at Low Water, read before the Congress of Inland Navigation in 1890). These dikes are given an elevation of 3 ft. above low water at their centers, which elevation gradually diminishes to low water at their ends. They are connected by wing dams that have the same elevation at their outer ends as the dike has at the point of junction, and gradually increase to an elevation of 5 ft. above low water at the bank.

These longitudinal dikes were completed in 1897, and have since received only minor repairs. The last survey of this section of the river was in 1901, and it is probable they had not then produced their full effect. The chief objection to their employment is their cost. If the channel can be forced against the river bank, the bank can be revetted cheaper than an artificial bank can be constructed in midstream. The wing dams are essential to either method.

The Des Moines Rapids Canal.

The Des Moines rapids extend from below Montrose, Ia., (mile 472), to Keokuk, Ia., 11.4 miles, measured between gages. The total fall at low water is 22.65 ft. The first project for improvement was submitted by Lieut. R. E. Lee, Corps of Engineers, U. S. Army, in 1837, and contemplated the improvement of the natural channel by the excavating of rock. Prior to the Civil War, about $350,000 had been expended on this project. In 1867, a board of engineers recommended the improvement of the rapids by the construction of a canal from Keokuk to Nashville, Ia., 7.6 miles; the upper 3.4 miles of the rapids to be improved by excavating a channel 200 ft. wide and 5 ft. below the low water of 1864, at an estimated cost of $2,530,000. The canal was opened for navigation in 1877.

The canal is 7.6 miles in length and extends along the Iowa shore from Keokuk to Nashville. The width proper is 300 ft. in embankment and 250 ft. in excavation, but owing to the irregularity of the shore, it stretches out in places to a width of 500 to 600 ft. The maximum depth is 8 ft., and the minimum is 5 ft. The fall at low water is 18.75 ft.

There are two lift locks and one guard lock, also used as a lift lock at high stages. Each has a lock chamber 350 × 80 ft. The lower lock is at Keokuk, the middle lock 2½ miles above, and the guard lock at the head of the canal, 7.6 miles above the lower lock. The lift of the lower lock at low water is 11.09 ft.; of the middle lock, 8 ft., and of the guard lock, 9 ft., at extreme high water. The lock gates are of wood, planked originally on the upper face. The lower gates of the lower lock, which are the heaviest, weigh 110,000 lbs. each. The gates close on miter sills and are suspended by means of heavy iron stay rods attached by swivels fastened to the tops of iron columns on the lock walls.

The culvert and lock gates are operated by hydraulic machinery designed by Major (now General) Amos Stickney, Corps of Engineers, who was in local charge during construction. In a well behind the recess of each lock gate are two vertical hydraulic cylinders; one for operating the lock gate, the other for operating the culvert gates. The pistons have a stroke slightly exceeding 6 ft.

The chains were constantly fouled by drift traveling along the bottom of the lock. Mr. M. Meigs, U. S. Civil Engineer, proposed a spar attached to the upper part of the gate, and this is used for the lower gates of all locks. The spar is an I-beam with one end attached to a pin on the gate and the other end running on a track on the lock wall. The wire ropes are attached to opposite ends of the spar.

The time required for opening or closing a pair of gates is about one minute; for filling or emptying the lock, about three minutes.

The faults of the original machinery system are as follows: The vertical position of the hydraulic cylinders requires them to be submerged, either wholly or partially, when the canal is full; this makes repairs and attention difficult. The scheme of chains under water, passing over submerged sheaves in the bottom of the gates, is bad. The chain fouls drift, trailing ropes, etc., and in case of breakage or wearing out they cannot be repaired without draining the canal. The space is too confined under the gate for a diver to be able to do effective work. The 29 years in which these locks have been operated emphasize the fact that all lock machinery should be kept above water if possible, or (if that is not possible) should be contrived so that it can be hoisted out for repairs with the least possible difficulty

and without having to drain the canal. Submerged machinery cannot be lubricated or be given proper inspection and care. Theoretically the application of the power to the top of the gate is bad, but in practice it does not twist the gate in any injurious manner, and its advantages greatly outweigh any theoretical defects.

In order to control the surplus water carried into the canal by numerous streams entering therein during their frequent floods, it became necessary to build sluices around the locks. These were not included in the original plans, and have materially increased the cost of the work. The dimensions of these sluices are as follows: At the lower lock, 18 ft. high, 16 ft. 2 ins. wide at the bottom, and 25 ft. 1¼ ins. at the top. At the middle lock, 15 ft. high, 17 ft. 7¼ ins. wide at bottom and 25 ft. 1¼ ins. on top. At the guard lock the sluice used as a feeder is in the outside embankment just below the lock. It is 19 ft. high and 38 ft. wide. All the sluices have six openings, 3 × 6 ft., with gates at the head, the lower ends being open.

The work on the canal was delayed by inadequate appropriations, and heavy losses were sustained on account of high water, overflows and natural waste. It was opened for navigation in 1877, but work on the original project continued to 1880, at which date it had cost $4,155,000.

A large item in the cost of maintenance has been the periodical dredging required to remove the deposits formed in the canal. While some sediment is deposited from the river water, the principal source of trouble is material washed in from the neighboring hills during storms. The creek at Sandusky during severe storms brings into the canal sufficient sand and gravel to interrupt navigation until a channel can be dredged through the obstruction.

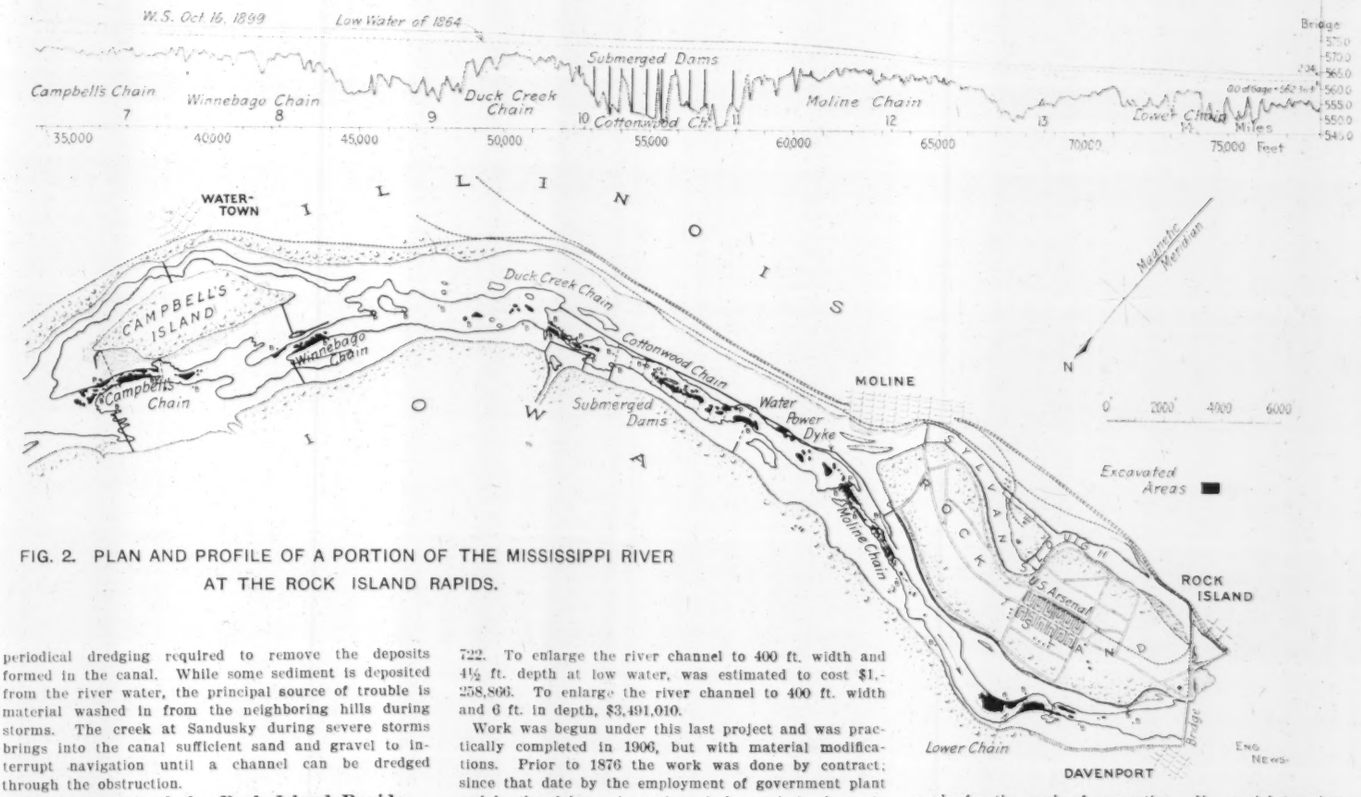


FIG. 2. PLAN AND PROFILE OF A PORTION OF THE MISSISSIPPI RIVER AT THE ROCK ISLAND RAPIDS.

Improvement of the Rock Island Rapids.

The Rock Island rapids extend from Le Claire, Ia., (mile 348), to the Rock Island Bridge, a distance of 14.26 miles. The fall at low water is 20.7 ft.; at the extreme high water of 1892, 15.2 ft. The bed of the river consists of a hard surface of limestone rock worn in many places into deep furrows by the long continued action of the water and the material washed along the bottom. There are also encountered a number of large granite boulders. The rock appears as reefs or chains across the river at twelve localities. There existed through these chains, prior to the improvement of the rapids, a narrow tortuous channel, which was navigated with difficulty, not only on account of lack of width and depth but also by reason of rapid cross currents and sharp turns. Between chains the channel was generally wide and navigable. The slope is not so uniformly distributed as on the Des Moines rapids, the channel consisting of a series of pools separated by chains over which the slope is steep.

In 1852, Congress made an appropriation of $100,000 for the improvement of the Rock Island and the Des Moines rapids. About $15,000 was expended on the Rock Island rapids. Work was then suspended until 1866, when a board of engineers recommended that the steamboat channel be enlarged by excavating to a minimum width of 200 ft. and a navigable depth of 4 ft. at low water. The recommendation was made in view of the economical execution of the work and the existing demands of commerce.

The board was also of the opinion that should the ultimate interests of commerce demand a greater depth than 4 ft., the plan of an independent canal and locks without dams would then best promote those interests, the practical result of such a plan being beyond question. The improvement that had been proposed by means of locks and dams across the river was considered inadvisable; it would form an obstruction permanent throughout the year, whereas at high and ordinary stages no hindrance to navigation existed.

It was estimated that to obtain a channel 200 ft. wide and 4 ft. deep at low water would require the removal of 57,451 cu. yds. of rock, at a cost of $813,601. The project was approved, and the work was completed in 1882 at a cost of $1,166,608 (87,926 cu. yds. of rock having been removed).

In 1888, a board of engineer officers was convened to prepare and submit a project for the further improvement of Rock Island rapids. The board submitted estimates for two methods of further improvement: (1) A canal around the rapids on the Illinois side of the river; (2) widening and deepening the present channel of the river at the rapids. The estimate for a canal 200 to 500 ft. wide and having a depth at low water increasing from 6 ft. at the head to about 12 ft. at the foot, was $3,704,722. To enlarge the river channel to 400 ft. width and 4½ ft. depth at low water, was estimated to cost $1,258,866. To enlarge the river channel to 400 ft. width and 6 ft. in depth, $3,491,010.

Work was begun under this last project and was practically completed in 1906, but with material modifications. Prior to 1876 the work was done by contract; since that date by the employment of government plant and by day labor. A portion of the work is shown in Fig. 2.

The methods of rock excavation employed were as follows: (1) by cofferdam, drilling by hand, and use of common blasting powder; (2) by chisel boat and dredge; (3) by drillboat, submarine blasting with dynamite, and removal of rock by dredge.

1. BY COFFERDAM.—The method of constructing the dams was as follows: A breakwater was first constructed about 10 ft. above the proposed dam, to break the force of the current, and afford comparatively still water on the downstream side. It consisted of a series of cribs, generally about 10 × 10 ft., spaced about 16 ft. apart in the clear, and sunk by being filled with stone. Strong timbers were then laid from one crib to another, and a sheathing of plank was placed along the connecting timbers with one end resting on the timbers and spiked to them, and the other end resting on the bottom, the plank being inclined at an angle of about 45° with the water's surface (Fig. 3).

Timber work for an upper corner of the dam was framed and sunk in its proper place with two pairs of lower wall timbers, one pair extending down stream and the other across, attached by means of tie rods to the frame work. The timbers of each pair were secured to each other by the middle tie rods, the outer ends being held up to the surface by a float. Small rafts were moved along on each side of the line of the cofferdam, to afford sufficient space for working. Another pair of lower wall timbers (or stringers) was then fastened by means of tie rods to the floating ends already in, and secured to one another as before. A pair of upper timbers located above the surface of the water was then attached to the fixed part of the dam.

Sinking planks were spiked to the pair of lower timbers nearest to the fixed part of the dam at right angles to their length and projecting below them as much as was found by sounding necessary to keep the lower wall timbers as nearly horizontal as possible. This pair of timbers was now sunk until the ends of the sinking plank rested on the bottom. The upper timbers were raised a few inches above the surface of the water and spiked to the sinking plank, the frame thus made being weighted to keep the timbers in place. The side planks (chamfered to a thin edge at the lower extremities) were then driven into close contact with the bottom and spiked to the top timbers, care being taken to keep them in contact with the lower timbers. The space was then ready for filling. The puddling or filling was taken from the river bed and shore, and consisted of clay mixed with gravel, which material was always found at moderate distances from the work. The construction is shown in Fig. 3.

After the filling became compact the water was slowly pumped out of the cofferdam and the space inclosed was ready for the work of excavation. No special tamping or packing was employed, the material being such as to readily settle and spread into the cavities. The size of timber and thickness of plank varied according to depth of water and consequent height of dam and pressure. In deep water, three rows of stringers were sometimes used as affording greater stability, and the dams were often braced from the inside at threatened points. The thickness of the filling of the upper and lower ends was about 10 ft., they being generally in deeper water than the sides, which had ordinarily an inside thickness of about 8 ft.

The dams used in the improvement of Rock Island rapids were in general built in comparatively shallow water (from 6 to 14 ft. in depth). Sycamore dam, which was the largest built, attained at some places a height of 26 ft. above the bed of the river.

The quarrying was performed by the use of the ordinary hand drill and blasting powder. The drills used varied from 1½ to 2½ ins. in diameter, and the depth of holes from 1 to 4 ft. To avoid the effect of moisture in the rock and to form a water-tight magazine, the holes were sponged out and partially filled with a soft pliable clay. The drill was then forced into this clay, pressing it against the sides and making a water-tight lining. The rock excavated was 7.13 cu. yds. to 1 lb. of powder.

When the excavation was finished and the inclosure

cleaned of broken rock, etc., the water was let in and the dams and cribs removed by dredges.

2. BY CHISEL AND DREDGE.—The chisel was used for breaking rock that was found in patches or in boulders too small in area to justify the construction of an inclosing cofferdam. The use of the chisel boat dates back to 1855, when Major J. G. Floyd, United States Agent, used on the Des Moines rapids a stick of oak timber 12 ft. long and about 12 ins. square, with bars of railway iron let into the side as ribbands to work in the uprights prepared for the purpose and set up on one end of the boat. The timber was shod with a conical shoe of wrought iron weighing about 300 lbs., and having a pyramidal point of steel. The chisels were afterwards made of wrought iron 9 ft. long with a steel point.

The upper end worked loosely in a "head" from which the chisel was suspended, and was so arranged as to allow the chisel to glance from the rock without injury to the boat. Its weight was about 3½ tons. The steel point was detachable, so that when it became dull it could be removed and another substituted. The "head" was made of tough elm or bass wood and raw hide bolted together so as to bring the raw hide at the neck of the chisel, where there was the greatest wear. The chisel was operated by machinery and leads similar to those of a pile driver, which were placed on a suitable flatboat. The fall was about 7 ft. The boat was maneuvered by anchors, lines and windlasses, so as to cover the points desired, the chisel working from the down stream end of the boat. On the Rock Island rapids the chisel was reported to be very efficacious where the cutting was small (18 ins. or less), while on the Des Moines rapids it was not as satisfactory.

3. BY DRILLBOAT, SUBMARINE BLASTING AND DREDGE.—In 1875, at St. Louis Chain, tripods were placed on the rock to be excavated, and from platforms built on the tripods holes were drilled by hand, the rock blasted, and the broken rock raised by a derrick boat. While this method can be employed advantageously for small patches of rock, it has been found with the development of the steam drill that it was more economical to mount the drill on a barge, which could be moved readily from place to place. Since 1878, the work of rock removal has been performed on the Rock Island rapids by means of the drillboat. The latest form of drillboat employed consists of a barge, 80 × 18 ft., on one side of which are mounted two steam drills. A boiler room and blacksmith shop occupy the middle of the boat, and the boat is held in position by spuds. Maneuvering lines are also attached for moving the boat out of danger during blasting operations.

The usual method of procedure is as follows: The drillboat is first spudded in position, and 3-in. holes are drilled 4 ft. apart to a depth of 3 ft. below grade to avoid reblasting. The distance between rows of drill holes is also usually 4 ft. The holes are then freed from debris by flushing them out with water discharged through a hose with a long nozzle. The charges of dynamite are dropped through a long tube having a slot in the side to accommodate the fuse wires, and a wad of old junk is rammed down on top of each load to hold it securely in place. The number of loaded holes on a line (ranging from 1 to 17) having been finally connected by splicing the wires to form a circuit, the drillboat is moved away to a distance of 50 to 75 ft., and the blast is then fired with a battery.

The average amount of dynamite used is 2.29 lbs. per solid cu. yd. of rock blasted, and the average amount of solid rock blasted per day of 16 hours by one drillboat is 30.86 cu. yds. There is great variation, however, due to depth of drilling, quality of material, and the amount of sand and gravel found overlying the reefs. In deep ledge rock which breaks up so as to permit holes to be drilled 8 ft. apart, an output of 72 cu. yds. of solid rock per day of 16 hours was obtained, with an expenditure of 1.17 lbs. of dynamite per cu. yd.

The quantity of dynamite generally used for holes of various depths and in different kinds of material is as follows:

Depth of hole, ft.	3	4	5	6	7	8
Dynamite in hard rock, lbs.	2½	3¼	4	4¾	5½	6¼
Dynamite in rock medium to soft, lbs.	2	2⅝	3¼	3⅞	4½	5¼

Harbors of Refuge.

The Mississippi River steamboats are broad and of light draft, and are not constructed to resist wave action. Storms on Lake Pepin create waves of considerable force, and have caused numerous accidents to river craft in their passage through it. Log and lumber rafts of large dimensions are towed through the lake, and, as the current in the lake is inappreciable, move very slowly. If exposed to a storm these rafts are broken up and scattered. The navigation interests have therefore desired some form of protection, and four piers or breakwaters have been constructed, on the leeward side of which vessels can find refuge.

The first of these was built at Stockholm. It has a length of 774 ft., the inner 166 ft. being a riprapped earth embankment, and the remainder composed of 18 cribs filled with rock and gravel. The cribs are 32 ft. long, 20 ft. and 26 ft. wide. The substructure was built of pine logs and the superstructure of 12-in. square timbers 6 ins. apart. Two sets of longitudinal timbers divide the cribs into pockets. The outer pockets were filled with rock and the inner originally with earth and gravel. The top was covered with 3-in. oak plank. The height of the breakwater is 12 ft. above the low water of 1864, and at its outer end has a height of 24 ft. from the bed of the lake. Snubbing posts were provided for mooring vessels and protecting oak piles driven along the sides of the structure. This work was done under contract, and completed in September, 1885.

The flood of the spring of 1888 broke up the ice in the lake when it was 2 ft. thick. A violent windstorm carried a large mass of this ice against the pier, and the upper 4 ft. of the superstructure was carried away. In making repairs, the sides and ends of the superstructure were given a slope and covered with 3-in. oak plank. The angles between the crib and the bed of the lake were filled with brush and rock substituted for the earth and gravel in the center pockets. Since these repairs have been made the structure has successfully withstood the action of ice and storms.

The Lake City breakwater has 512 ft. of cribs and 359 ft. of embankment. The embankment is built of gravel dredged from the bed of the lake, has a width of 17 ft. on top and a height of 13 ft. above low water. The slopes above low water are 1 on 1½, and are covered with a layer of riprap rock. The cribs rest on a gravel foundation, deposited from dump scows, which reduced the depth of the lake along the line of the pier from a maximum of 28 ft. to 5 ft. below low water. The cribs are similar to those in the Stockholm breakwater, except that they have a width of 32 ft., and on the harbor side the superstructure is vertical and sheathed with 2-in. oak planks. It was observed that the embankments at the shore ends of the breakwater suffered less from ice than the timber structures, and at Kings Coulee the experiment was tried of extending the embankment the entire length of the breakwater. A foundation of gravel was deposited to a stage 5 ft. below low water, and on this a dam was constructed of brush and rock, the brush being woven into mats and sunk in the usual manner. The length of pier is 700 ft. For 650 ft. it was built to a stage 12 ft. above low water, the outer 50 ft. gradually sloping to a grade 4 ft. above datum. The width of the pier is 10 ft. on top and 36 ft. at the low water line.

The slopes above low water are 13 ft. horizontal to 12 ft. vertical, and below low water the natural slope of gravel under water, about 1 on 4. The surface of the breakwater is covered with a riprap of stone from 3½ to 4 ft. thick at low water and diminishing to 2 ft. in thickness at the top. Snubbing posts were provided for mooring vessels.

A fourth breakwater at North Pepin has a length of about 1,000 ft., but is built in shoaler water than the other three. It is composed of a sand and gravel core, covered with riprap rock.

Ice Harbors.

When the ice breaks up in the spring, it frequently floats down the river in masses sufficiently large to destroy any boat with which it may come in contact, and it is necessary for boats to lie up during the winter at places where they will not be exposed to this action. The outlet of a side slough frequently affords such protection, and a number of sloughs are used as ice harbors for rafts of logs. The Des Moines rapids canal and the portion of the Illinois & Mississippi canal around the rapids of Rock River are also extensively employed for a similar purpose. For steamboats it is desirable that the ice harbor should be in the vicinity of some large town, so that the necessary repairs for another season can be made while the boat is laid up. Appropriations have been made for ice harbors, at Dubuque, Ia., (mile 265), at Davenport, Ia., (mile 363), and at Quincy, Ill. (mile 521).

The ice harbor at Dubuque has been constructed by the general government deepening Waples Cut, a natural harbor in front of the city, while the local authorities have filled in around it. The harbor has an area of about 12 acres and has been dredged to a depth of 6 ft. below low water. At Davenport a harbor has been constructed behind Credit Island by building a dam across the upper end of the slough and dredging to 5 ft. below low water. The dam was originally given a height of 8 ft. above low water by the government, but afterwards raised to 13 ft. by a railway company.

In the bay above Quincy, Ill., an area of 82 acres has been dredged to a depth of 6 ft. below low water. This harbor not only affords refuge for boats, but a large portion is occupied by log rafts stored for the use of mills in the vicinity. There is considerable deposit in the bay from streams and sewers emptying into it, which has to be removed by dredging.

Appropriations have been made for improving the river in front of certain cities and towns along the river, and these have been frequently designated as "improving the harbor" at the locality. In such cases the work to be done usually consists in removing a bar which has been formed in front of the steamboat landing of the town by sand moving down the river. The methods of improvement adopted have been either dredging, or contracting the width of the river by the construction of wing dams on the bank opposite the town, so as to cause the river currents to remove the obstructing bar.

A lock is under construction in front of Moline to afford that city a connection with the river, but as this lock will become a portion of the enlarged project for improving the river its description is omitted.

Levees.

At a 6-ft. stage the river begins to overflow the bottom lands; above a 12-ft. stage the overflow of the alluvial valley is extensive, although there are certain sand ridges that are above any recorded stage of the river. The floods are usually of short duration, and most frequently occur in June or July. While there are many tracts of land that have been partially protected from overflow by their owners, there are but three levee districts along the upper Mississippi River that have received appropriations from the general government, the levee from Iowa River to Flint Creek, Warsaw to Quincy Levee, and Sny Levee.

FLINT CREEK LEVEE.—This levee has a length of 35¼ miles and protects from overflow about 44,700 acres. The levee section originally adopted had a width of crown of 4 ft., land slope 1 on 2, and river slope of 1 on 3. The grade of crown is 3 ft. above the flood of 1888. When the writer was assigned to the charge of the district, in 1898, he increased the section by giving a width of 6 ft. to the crown and a land slope of 1 on 2½. The levee section adopted on the lower Mississippi River, which has a crown from 8 to 10 ft. wide and a land slope of 1 on 3, it was believed, could be safely reduced, as the floods on the upper river are of shorter duration, and as great an increase in flood height from levee construction is not to be apprehended.

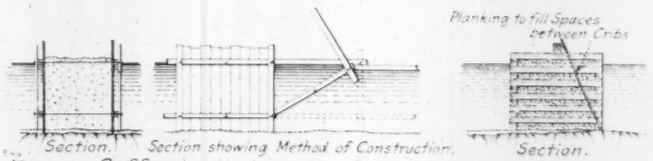


FIG. 3. BREAKWATER AND COFFERDAM FOR RIVER IMPROVEMENT WORK.
(To permit of Rock Excavation in the Dry.)

LEVEE CONSTRUCTION.—The ground occupied by the levee was first cleared of trees, stumps, and all other perishable matter, all trees and stumps being grubbed out by the roots to 3 ft. beyond the slope stakes. The surface of the ground was then thoroughly broken by spade or plow to form a bond with the earth deposited. The specifications required that such top soil as in the opinion of the engineer in charge was unfit for the foundation should be removed and deposited to form a banquette on the land side of the levee, together with such top soil from the borrow pits. But the ground along the levee was of such a character that little material was rejected. A muck ditch (usually 4 × 4 ft.) was then cut 3 ft. from the center line of the levee on the river side. Its object is to explore the foundation and the embankment. The ditch was then filled with approved material and thoroughly tamped, usually by teams passing over it.

The embankment was then deposited in layers not exceeding 2 ft. when moved by scrapers (the usual method). If constructed by wheelbarrows, the specifications prescribed that the layers should not exceed 1 ft. in thickness and should be carefully tamped by employing one rammer to two wheelbarrows. The embankment was carried to one-tenth its height above the established grade to allow for shrinkage. The material was generally obtained from borrow pits on the river side, at a distance not less than 20 ft. from the base of the levee, but in a few cases it was necessary to obtain a small portion of the material on the land side, and in such cases the limit of the borrow pits was 60 ft. from the toe of the land slope.

As the levee line extends to the bluffs at the lower end of the district, to protect against back water, it has been necessary to make provision for the ordinary drainage of the land during rain storms. This has been accomplished by running pipes with outflow valves through the embankment at the various sloughs and streams it crosses, so that when the river is low, water can flow outward, but if high the closed valve would prevent an inflow. Ordinary 36-in. cast-iron water mains were em-

ployed, having an average weight of 4,200 lbs. for lengths to lay 12 ft. The pipes were laid without calking the joints.

Three kinds of outflow valves have been tried. The first was an iron valve with pipe about 5 ft. long, which cost $86.43. The second was also an iron valve, about half as long as the first, and with a flange on the lip, and planed faces, which made a tighter and better joint. This cost $70. But with both these valves it was found that a head of water of about 1 ft. was necessary to open the valve, unless a counterbalance was provided. This counterbalance consisted of an old rail attached to the valve by a wire rope and so pivoted as to take up the surplus weight. A wooden shutter, costing about $11, was used also. The objection to the wooden valves is their tendency to warp in such a manner as to allow considerable leakage. They are also more easily broken than the iron valves.

At the outlet of these drainage pipes were built rubble retaining walls to prevent earth from sliding in and filling the pipes; and an apron was also constructed to receive the outflow and prevent erosion. On the land side of the levee the entrances to the drainage pipes were protected by a riprap of rock. When the levee was exposed to wave wash, the slope was revetted with a 9-in. layer of riprap, extending from the toe of the slope to an elevation about 1 ft. below the high water of 1888. The rest of the levee slope was sown with grass seed, so as to form a sod to protect the embankment from rain wash.

It was occasionally necessary to construct the levee close to the bank of the river or a slough where it was liable to be injured by the caving of the banks. In such cases the bank was revetted. These shore protections were constructed in the manner customary on the upper Mississippi River. This levee successfully withstood the flood of June, 1903, which at the upper end of the levee district was the highest on record.

WARSAW TO QUINCY LEVEE (Miles 489-520).—This was built by local levee boards from 1881 to 1888, with a cross-section having a width of crown of 5 ft., a land slope of 1 on 2 and a river slope of 1 on 3. It has a length of about 40 miles and protects from overflow about 52,000 acres of land. There has been expended by the United States in raising and strengthening this Levee to June 30, 1906, $101,428.

SNY LEVEE (Miles 533-584).—This extends from the bluffs below Quincy, Ill., to Hamburg Bay, and protects an area of about 124,500 acres. It was originally constructed with a cross section similar to the Warsaw levee, but has since been enlarged to a triangular section with a land slope of 1 on 2 and a river slope of 1 on 3, the apex being 5 ft. above the high water of 1892. There has been expended by the United States on this levee $106,728.99, $50,000 for levee enlargement and the remainder for the protection of the levee from caving banks.

Removal of Snags and Other Obstructions.

In 1867 an appropriation of $96,000 was made for building and operating two dredge and snag boats. Two steamboats were purchased and equipped with shears, for pulling snags, and with Long's scraper, for lowering the crests of sand bars. This scraper, an invention of the late Col. Stephen H. Long, Corps of Engineers, appears to have been the most successful of the various devices that have been suggested to temporarily improve navigation during low water. It consisted of a triangular frame of oak timber, with buckets or cutters of boiler iron bolted to the lower side. It was attached by bolts to the sides of the boat, and was raised or lowered by ropes.

The method of operating the scraper was to move the boat to the head of the shoal to be dredged, and to lower the scraper on the bar; the wheels of the steamer were then backed so as to drag the scraper over the bar, the boat floating with its stern down stream. After having been dragged across the bar, the scraper was raised out of the water and the steamer returned to the initial point. The operation was then repeated until the desired depth was obtained. The buckets cut up and loosened the material on the bar and then conveyed it down stream and deposited it in deep water, being assisted in the movement of the material by the river currents.

These scrapers were quite extensively employed until appropriations were made for the permanent improvement of the river, when dredges were substituted for them. In the report of the Chief of Engineers for 1880 (page 1485) it is stated as follows:

> The results not being commensurate with the amount of time and labor required, comparatively little of this kind of work has been done of late years. So many bars scattered over the entire 700 miles of river becoming obstructions simultaneously at each recurring low-water, it was found a hopeless task to keep them all open with one boat, and unless a channel is cut through all and maintained the work cannot be considered successful. And again, the results have no permanency, the work of the scraper being generally obliterated at each rise of the river, however slight, and in many cases a single night will destroy the work of the previous day. In increasing the depth on a bar for the time being the scraper is generally very effective and is now often used in special cases where it is thought that a channel once cut will maintain itself.

In such cases, however, it was found that the ordinary dipper dredge was more economical, and the work of the boat has been confined to snagging operations and the removal of wrecks and boulders.

In the removal of rocks, wrecks and cribs the dipper dredge has been found to be the best instrument, and is now more commonly used. Since the abandonment of the scraper, dipper and suction dredges have been used under this appropriation in cutting temporary channels by removing sand obstructions. A large amount of rock excavation has also been performed by use of steam-drill boats, dynamite and dipper dredge. For work above enumerated there is an annual appropriation of $25,000.

Publicity for Railway Accidents.*

By W. L. PARK.†

Any practice which will reduce the number of avoidable accidents or railways is eagerly sought for, and the placing of responsibility where it belongs in case they do occur, is only just to those who suffer thereby, either physically, financially or mentally.

Statistics of railway accidents are accessible to all and quite well known. I desire to refer to them briefly in so far as they relate to casualties to persons. From the Interstate Commerce Commission reports we learn that for the year ending June 30, 1906, the total number was 108,324, of which 10,618 were fatalities and 97,706 personal injuries. There were 359 passengers killed and 10,764 injured; 3,929 employees killed and 76,701 injured; outsiders, 6,330 killed and 10,241 injured. For the year ending June 30, 1907, there were 3,764 persons killed and 68,989 injured. While there is apparently a very marked diminution in the casualties, we know that it is in proportion to the lessened volume of business, and that accidents increase in greater ratio than an increase in business, for many reasons.

As railway men we must admit that the long list of appalling accidents, accompanied with fatalities and personal injuries to passengers and employees, many of which were avoidable, is a blot on our escutcheon which must be wiped out. How this may be accomplished is the one great problem confronting operating officials and employees. The solution unquestionably lies in the direction of taking the public into our confidence, making them feel that they have as great responsibility in upholding the law of discipline on railways as they have in upholding the law in the government of the ordinary affairs of life. Publicity for accidents, placing the same responsibility upon those who violate the rules of safety as is now placed upon those who in other ways do the public a harm, will certainly bring about a very different conception of duty.

Railway men of sufficient length of service cannot fail to compare the *esprit de corps* of a few years ago with conditions existing on American railways to-day. Instead of that intense interest and voluntary loyalty, we have a lethargic performance of duty, and a very pronounced indifference to the employer's interests, with almost studied effort to render such service only as may be contracted for, to the extent that on some railways there is actually in vogue a system of fines assessed against trainmen who do more than their schedules provide, and those who are known as "company men" are unpopular among their fellows everywhere. The loss of this voluntary loyalty is most severely felt in the discipline. The pecuniary losses (through indifference inviting adverse public sentiment) are great and to be deplored, but the loss of reputation and confidence in railroad management is one that falls heavily on every official and employee connected with a railroad, making them vulnerable to the attacks of enemies, who are ever watchful of such opportunities.

While we do not contend that the employees' organizations sanction or even encourage indifference, force of circumstances undoubtedly carries the members under their protection into such a line of thought and action that the service is unconsciously tainted thereby. Such influence of organizations is not by any means confined to the members. It affects other employees, and even the officials, who are expected to administer discipline impartially, influencing their decisions through fear of being reversed by superiors, who may be actuated by motives foreign to the case under consideration.

The responsibility is not, by any means, entirely with the rank and file. Employees in self-defense have been forced into cooperation for mutual protection against petty persecutions and discriminations on the part of the railway officials. The organizations are expensive to maintain and, at times, exact from the members sacrifices not in accord with the spirit of independence bequeathed them in the Declaration of Independence. The yoke is galling, but must be worn until such time as officials are so surrounded with established methods of discipline as will do away with the injustice and vindictiveness in fixing penalties. Our present system is primitive and barberous, it insults the intelligence of employees and forces them into alliances for self-protection. Once having the power, they naturally exercise it in directions not originally intended.

While I may be telling a family secret, it is a fact that not a few railway accidents are white-washed in the investigation to the extent that the officials even deceive themselves. The evidence is often made to substantiate a preconceived conclusion as to how the incident occurred. The dominant influence of one in authority frequently asserts itself to the extent that the interrogating or giving of testimony is shaped to meet the well known views of a superior. This influence may be unconsciously exerted or absorbed.

If our English cousins, through the Board of Trade can investigate accidents with unquestionable diminution as a result, and the German and other powers of continental Europe through ministers of railway affairs, can bring the heavy hand of the government to bear upon the transgressor of good practice (whether he be employee or official) to the end that few avoidable accidents occur, it is not looking far ahead to find our duties circumscribed by conditions much more perplexing than now exist. It is not certain by any means that we shall stop with that which satisfies the conservative Englishman or phlegmatic German. We are not yet old enough to assume such responsibilities.

Unless railway men are willing to let the politicians take from their hands the reins and govern the roads with inexperience and theory, they must analyze the present conditions and shape the future policy in this respect in accord with the growing sentiment that accidents are of too frequent occurrence and, unless prevented to a greater degree than now obtains, the strong arm of the government must intervene, be the consequences what they may. Unless railway managers merit such confidence by an impartial and thorough investigation of such accidents as disturb the public welfare, such power will be taken from them. A competent railway operating official ought not to fear publicity for accidents. He should be so well grounded in his methods as to invite publicity. The public will help him to place the responsibility where it belongs, and secure for him the individual responsibility, which is essential to any well managed property. As it now stands, the managers must bear wholly the odium of a disregard of the rules. If an accident occurs the men implicated will frequently accuse the officials of not enforcing the rule, a violation of which was responsible, alleging that custom superseded it.

The Union Pacific is perhaps the first railway adopting this method. We approached it with no little timidity. Our legal department said it would throw open information upon which claims would be made for damages and personal injuries. As a matter of fact nothing of this kind has occurred. On the contrary, the accident having been thrown open to full public investigation, there are no mysteries for the opposition to delve into; no vague insinuation that the great corporation is crushing the helpless client by suppressing the facts (which is always a stock in trade with the plaintiff in a damage case). That such investigation helps the legal department there is no doubt.

A board of inquiry convened Dec. 3 at Cheyenne, Wyo., for the purpose of investigating a collision which occurred at Borie, Wyo., on Nov. 10. An eastbound freight train, descending the east slope of Sherman Hill became uncontrollable, striking a work engine and way car, which had been employed on the Carr-Borie cut-off, killing ten employees. Special tests were made of air appliances and their effect on trains. Experts in the operation and the use of air brakes as well as a large number of employees were interrogated. The findings of the board were as follows:

> The evidence shows leaving Buford extra 223 had a train line air pressure of 90 lbs.; at a point between Ozone and Buford this pressure was reduced to 40 lbs., the conductor having stated that frequent applications and releases of air had been made without the necessary time being allowed for the train line to recharge. We believe that the accident was caused by the improper manipulation of air by Engineer Schley of engine 223, which resulted in his not having the necessary pressure to control the train when the emergency arose.
>
> We further find and believe that had prompt and proper response been given by the crew with hand brakes, the speed of this train would have been checked and controlled in ample time to have prevented the accident. Charles C. Hughes, Chairman, General Superintendent, C. & N. W. Ry. (retired); George M. Randall, Major General, U. S. A.; Frank D. Baldwin, Brigadier General, U. S. A.; W. B. Scott, Assistant Director Maintenance and Operation, Union Pacific System—Southern Pacific Co.; H. H. Forney, General Air Brake Inspector, Southern Pacific Co.; A. L. Mohler, Vice-President and General Manager, Union Pacific Ry.; W. L. Park, General Superintendent, Union Pacific Ry.

This is the first investigation of this character in which United States army officers participated. The long army experience of these two military men, with absolute independence of action, gave them the requisite qualifications to conduct an unbiased investigation and render an opinion without fear or favor.

It is alleged frequently in case of a locomotive boiler explosion that there was an inherent weakness. Board of inquiry composed of division officials and ex-Governor John R. Osborne (of Wyoming) found as follows:

*Abstract of a paper read at the March meeting of the Western Railway Club, Chicago.

†General Superintendent, Union Pacific Ry., Omaha, Neb.

The explosion of engine 1647 was due to low water and overheated crown sheet. The responsibility rests entirely with the engine crew.

Investigation showed that the crown sheet gave way through the eleventh row of stays from flue sheet, breaking entirely in two; through this row of holes from side seam to side seam, 18 holes across top of box. The break from side seam angles backward, terminating at 14th row from mud ring, left side: The side seam, left side, sheared rivets from break across crown sheet forward to the tee iron, balance of seams pulled down with crown, dragging sides with them to the point before mentioned. Buttonhead bolts in the tee iron did not pull through part of crown back of these, to break in sheet, which occurred in 11th row of stays laying against flues. That part of crown back of the break pulled loose, coming below mud ring 12 ins. and is 28 ins. at this point ahead of door sheet.

Crown was red hot nearly ten rows of stays in width at flue sheet and 8 ins. wide at 5th row of stays from door, making red hot section nearly 4 ins. in width of flue sheet and 8 ins. wide at 18 ins. from door sheet. About six radial stays and stay bolts stripped off firebox sheet, none of these bolts broken. Casing sheets, boiler head and mud ring badly bent outward, excepting at top where they are dented in by boiler striking at this point in its fall. The smoke stack was still on smoke box, which was on the boiler, while extension is torn off and lays under cylinders. The crew concerned in this accident arrived at Green River 12.20 p. m. and left at 12.50 a. m., having had 24 hrs. 30 mins. rest.

(Signed) John R. Osborne, ex-Governor, Wyoming; H. L. Anderson, Superintendent; Wm. Niland, Master Mechanic; A. J. Wharf, Division Engineer.

River Bank Protection in Northern India by Stone-Filled Wire Net Cylinders.

Those engineers in this country who are fighting the inroads of sudden floods in rivers watered from a drainage area having an annual rainfall of some 40 or 50 ins. and a maximum weekly rainfall, say, of 15 ins., will be interested in the experiences of railway engineers in the north of the Indian peninsula where the rainfall on the river heads in the Himalayas is 600 to 700 ins. per annum and reaches occasionally as high as 26 ins. in 24 hours. In a recent paper* before the Institution of Civil Engineers, Mr. Francis P. Anderson describes river protection work in this country, from which we here abstract the more important parts.

This protection work was principally along the abutments and approaches of various bridges along the line of the Bengal Dooars Ry. Mr. Anderson says:

The Bengal Dooars Railway lies along the left bank of the Tista River to Mal Bazar, about 92 miles north of the junction and mainly serves the tract of country called the Bengal Dooars, from which the railway derives its name. It possesses several features of great engineering interest. The peculiar features result mainly from the alinement, which is along the glacis of the Bhutan Himalayas, between the level alluvial plain and the steep hills, and at a distance ranging from 1 to 10 miles from the latter; it crosses several large rivers, which drain mountains up to 15,000 ft. in height, though the altitude of the railway itself never rises to more than 700 ft.

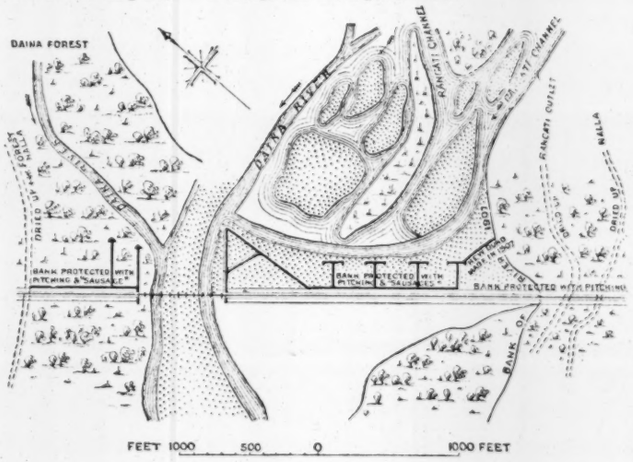
The proximity of the railway to the points where the rivers debouch from the mountains brings about this curious fact, that the largest rivers and bridges on the line are at the summits of the steepest and longest gradients. The explanation of this paradox is as follows: These rivers have brought down with them an enormous amount of debris, consisting of clay, sand, shingle, and boulders, which has spread fanwise over the country with the joint of the fan at the point of debouchment. The rivers usually occupy a shallow depression in the highest ridge of the fan and drain the Himalayan valleys, the valleys between the fans being drained by smaller streams taking the local rainfall; while the railway, which lies parallel to the mountain range, has to rise up over these mounds of debris.

It will thus be perceived that there are two problems to be dealt with, namely, that of the local rainfall drained by the smaller streams in the valleys between the fans, and that of the mountain rainfall drained by the rivers on the top of their mounds of debris. The local rainfall at and near the line of railway may be estimated, as a maximum, at about 210 ins. per annum. Of the mountain rainfall no measurement is recorded, but it is estimated, from reliable data, to be about 735 ins. per annum. Besides the rainfall the other somewhat abnormal feature of the railway consists in the steepness of the water-gradients of the rivers. These in some cases become as much as 50 ft. to the mile even near the railway; and the volume of silt and debris brought down by the streams is thus due to the enormous rainfall, the steepness of the water-courses, and the friability of the Himalayan Mountains. The amount of silt is so great that it may turn a large river from its bed in a single day, and there have been two such deviations in the last three years. This is perhaps due to the fact that floods of high velocity bear with them a considerable amount of debris; when the rainfall moderates, the flood also moderates in volume and velocity, and a quantity of solid matter is left stranded. This serves to heap the water back and with the ill-defined banks gives time for it to enlarge an opening already begun during the heavy flood; through such an opening the river may take its course in subsequent years until there is again sufficient accumulation to provide a fresh change. The discharge of debris by the rivers constitutes now the main difficulty in the maintenance of this part of the railway.

When the railway was first made it appears to have been assumed that the rainfall in the mountains was the same as that of the lower belt of country. It proved necessary therefore to enlarge some of the bridges from time to time. But these measures by themselves were deemed insufficient, so in every case except one the bridges have been floored, and including this structure, the approaches to all bridges have been protected with abutment-spurs (Bell bunds) and other subsidiary spurs.

The usual Bell bund is an embankment of earth protected by stone-pitching; it originates at the abutment and terminates up-stream in what Indian engineers call the impregnable head. Such spurs, however, would not withstand the impact of rivers in the Dooars a single rainy season, and therefore the device of making them of boulders enclosed in wire netting was employed. This device was originally employed on the Harnai and the Assam-Bengal railways, but nowhere on the scale employed on the Bengal-Dooars Railway.

WIRE NETS.—The method consists in making a wire net 50 × 16 ft., placing it in position and bending it to the necessary curve; then the longitudinal edges are joined and tied, boulders are filled in and the ends are finally fastened up; the shape assumed when complete is something like a sausage and accordingly the device goes by that name. The nets are woven in the following manner: two rails, parallel to one another, are made fast to the ground; they are placed about 75 ft. apart in order to allow for the slack necessary in tying up the ends; galvanized-steel wires, No. 6 B. W. G., are then stretched 6 ins. apart from rail to rail, every sixth wire being double. The web wires are interlaced at similar distances with double wires at the same intervals, and at every intersection the wires are tied with tying wire, No. 10 B. W. G.; the tying wires are each about 6 ins. long and are bent round the intersection three times; no knot is made in either wire, as it is found that the friction is quite sufficient to keep the longitudinal end cross wires from running together.



MAP OF THE DAINA BRIDGE ACROSS THE DAINA AND RANGATI RIVERS, BENGAL, INDIA.

(Showing final state of the bank protection works.)

After the ground has been prepared so as to bed the "sausage" properly, the selvages are tied together, forming thereby a wire cage 50 ft. long and 5 ft. in diameter. The stuffing consists of small boulders, small because, so long as they are too large to go through the mesh, they pack better and are easier to handle. The stones are handed from the ends to men inside, and when full the ends are tied, thus completing the sausage.

The cost of the sausage is about £8 ($38). Such a monolith accepts the various inequalities of the ground without disturbance, and even if undercut and sinking, does not lose much of its integrity, as the desired effect can be again assured by the superposition of another sausage. The author understands from experience on the Harnai Ry. that the life of one of these sausages is 15 years if unattacked by any abnormal stress from floods, i. e., the rusting of the wires will not bring about an earlier destruction. On this railway, although many have been destroyed by the fury of the impact of the water, none so far have been destroyed by process of time, but then the experience covers only about 6 years. The sausages have been used for several purposes, one to guide the stream to a line normal to the longitudinal section of the bridge, another for the construction of spurs to break up the impact of the current by "ponding" the water, and they can also be used as protection walls. When used in the last capacity they are laid along the talus of the bank, one superimposed on the other to the required height. When used as spurs they are laid, when viewed in section, pyramid fashion, in groups of three or six or even more.

In some cases an additional sausage, at a distance of 15 ft. from the bottom tier, has been laid, the interspace being filled with boulders and covered with a wire net.

USE OF NET AT THE DAINA BRIDGE.—It now remains to describe the uses to which this wire net-work device has been put in the endeavor to control the streams bridged by the railway. Before entering at length on a specific instance, it may be well to describe some characteristics of the beds of the larger rivers. It has already been shown that the rivers, after draining the mountain valleys, debouch on to the top of the debris they have brought down, and flow in ill-defined channels along the top of this down to the great Gangetic plain. But the point of debouchment may be, and often is, the meeting place of two or three valleys, and the streams from each will keep themselves quite distinct for several miles, owing to the great width of the water-courses, which is often as much as a mile at low water. In flood-time the streams from the different valleys mingle early in their course; and hence it is that the water, draining from three different valleys, with different shades, clear, whitish, and reddish, may often be seen to mingle a little above and then pass under the Ghish bridge. The Daina bridge likewise really takes two large streams, the Daina and the Rangati. (See accompanying figure.) In nearly all cases such water-courses have one very ill-defined bank, whilst the other forms a low cliff, the edge of a spur prolonged from the mountain, but in some cases both banks are ill-defined. This separation of two different streams in the same water-course has some bearing on the question of river control. As mentioned, the water-courses themselves are often a mile wide and more, the beds being composed of sand, shingle, and boulders, and largely occupied by vegetation, consisting of tall grass and trees up to 60 ft. high. With a channel of such width, the water has room to spread itself and thus these islands are only submerged in the highest floods.

To give an instance of one of these rivers whose streams have been controlled more or less successfully by the means herein described, none suits so well as the Daina. This river is in reality two streams, the Daina proper and the Rangati; and the two, after draining many valleys in the Bhutan Himalaya, debouch from one gorge on to their common heap of debris. The mountains along which these valleys lie are lofty, some of them rising to 12,000 ft. in height. The railway across the river was built in 1901-1902, and the total width of the water-course, that is, the area of land covered by the swiftly flowing water in time of flood, is about 5,000 ft. The drainage-area is 97.6 sq. mi., and the rise of the river-bed from the railway is about 50 ft. to the mile, increasing fast as the river-bed nears the mountains about 7 miles away.

The discharge of the river, assuming a rainfall of 210 ins. (the rainfall along the line of railway), is about 69,000 cu. ft. per sec. This, however, must be much below the actual flood discharge. With this discharge the wetted area of section at the bridge gives a velocity of 10.1 ft. per sec., which would be proportionally greater for the more probable discharge.

To bridge this river it was decided that ten spans of 60-ft. girders would suffice. The bridge was situated at the lowest point of the cross-section of the water-course and the remainder was crossed with an earthen bank.

During the first rainy season, that of 1903, the bank across the watercourse was breached at intervals from end to end, the most important breaches being at the two abutments, and at that part of the watercourse constituting the Rangati channels.

The summit level (691 ft.) of the line is at Chengmari station, ½ mile west of the Daina River, the grade of the Daina Bridge being 677 ft. above sea-level. When the line was made in 1903, this level was run out 600 ft. east whence it dropped 6 ft. in 4,500 ft., thereby giving a minimum of earthwork across the watercourse.

* "River Control by Wire Net Work," by Francis Philip Anderson, M. Inst. C. E. Paper (No. 3748) presented to the Institution of Civil Engineers.

To remedy the weakness disclosed by the extensive breaching of the railway across the watercourse it was decided to raise the grade throughout to the level of the bridge, and to strengthen the bank with wire-net protection-work. This was accordingly carried out in the following manner: Between the west bank of the river and the west end of the bridge, one spur of sausage-work was put in, about 200 ft. long, and at the west abutment a specially large spur 250 ft. long was laid; these spurs were provided with semi-circular heads, made of sausages, and hearted with boulders. At the east abutment a large protection scheme of sausage-work was instituted and carried out in the form of a trapezium, the long side, the base on the railway bank, having a length of 600 ft. Between the trapezium and the eastern bank four sausage-spurs were laid, each provided with a T-head; and attempts were also made to floor the bridge. These repairs occupied the season 1903-1904.

The rains of 1904 were comparatively moderate; nevertheless, the Rangati again succeeded in breaching the eastern approach to the bridge in two places, one 210 ft., the other 330 ft. long. Another defect was due to the island immediately up-stream of the bridge. This island was of considerable antiquity, for the saplings and Sissoo trees on it were at least 50 ft. high; but its effect, with the Rangati channels blocked by the railway bank, was to deflect the water of that river so that it impinged obliquely on to the bridge and added to the stresses to be borne by it. In the season 1904-5 it was therefore decided to remove the island and induce the current to flow in a line directly normal to the bridge. This was brought about by adding to the trapezium alluded to previously a triangular portion, so that the whole structure resembles in plan the letter A slightly distorted and leaning towards the left. The distance of the apex from the railway was about 630 ft. At the same time the spur from the west abutment was lengthened 100 ft. and the bridge was floored throughout with a floor 3 ft. thick and 50 ft. wide, together with an apron of the same thickness and 30 ft. wide running the length of the floor. The spurs of the western approach were also lengthened, the up-stream bank was filled in with a 3-to-1 slope and pitched with boulders from top to talus, the talus at the same time being protected by single sausages laid lengthways.

The rainy season of 1905 was not without floods; on one occasion 11 ins. fell in 24 hours, but though a little damage was done to the floor, two or three spans being scoured out, the protection-works all answered admirably. The island above the bridge was removed, as intended, by the stream being diverted against it from off the prolonged spur-work, so that the current was no longer deflected obliquely on to the bridge. The approach banks across the watercourse were also unharmed; but one thing had occurred to which sufficient importance was not attached at the time, namely, the up-stream side of the bank was so much silted up that the spurs were nearly blinded, and the bank, formerly 15 ft. high in the clear, was now no higher than 8 ft. At the time this result was looked upon with satisfaction, as thick vegetation quickly grew on the new deposit, and the whole seemed to add to the stability of the bank.

In August, 1906, the whole structure, bridge, earth-work and protection-work was compelled to withstand a very rude test, from which it emerged, not indeed scatheless, but still with some credit. July had been very wet; 45 ins. or thereabouts fell during that month, 30 ins. in the first three days of August, and between 10 a. m. of the 4th and the same hour on the 5th a fall of about 18 ins. was recorded. These records are taken from the tea-garden rain-gages near the line. How much rain fell nearer the base of the hills is not known, for the rain-gages were all filled to overflowing; neither is it possible to tell how much fell in the hills, a fall of 26 ins. in the 24 hours has been recorded at Cherra Punji, and a like amount, or more may have fallen in the Bhutan mountains on that day or night. The effect of this prodigious rainfall on the two branches of the railway in the Dooars was most destructive, the line being breached at intervals from end to end, and great gaps, one 800 ft. long, were made in the embankment. As for the bridges, several which had withstood the rains of 15 years were demolished.

At the Daina, the effect of the impact of the enormous volume of water was most interesting; although the bridge survived, the wire protection-works were damaged, the end of the west abutment spur being torn off and the top of the A-shaped protection-work at the east abutment being also demolished. The T-head of the easternmost spur was in like predicament, and beyond that point, the river after cutting into the east bank had effected a breach about 600 ft. wide. The author visited the scene on the afternoon before the night on which the maximum rainfall occurred, above the railway the river was a mile wide, moving at a great velocity and bearing with it large trees and other debris, the whole pouring through under the girders of the bridge and through the gap. Below the bridge were four or five standing waves at least as high as rail-level. As mentioned, the bank, besides being protected with spur-work, was also protected with pitching, and this pitching had been carried to a point at least ½ mile east of the gap. Now, between the bridge and the gap, but especially near the latter, the ballast had been washed out from under the sleepers and the down-stream slope of the bank was guttered, whereas the up-stream slope protected by the sausage-work and the pitching was unharmed. It is evident, then, that the water had risen above the level of the top of the bank, and after removing the ballast, had guttered away the down-stream slope until a great volume of the stream poured through the gap it had made. This leap of water over the top of the bank is obviously the result of the silting on the up-stream side, had there been no silt the water would have been deflected to the bridge in a line more or less parallel to the bank; but as it was, the water impelled by its enormous velocity and unable to break through the pitching, swept over the top, removed the ballast, and scoured the down-stream slope. In view of the fact that 18 ins. of rain fell in the 24 hours after this great gap had been made, it is doubtful if the bridge would have stood had there been no gap to ease the pressure on it. On the other hand, the sausage protection-work did its duty well, and protected the railway embankment effectively. The gap caused by the flood was east of this protection and was effected by the cutting in and removal of the river bank. No harm was done to the bridge itself, but the floor of three spans had been washed out, this being discovered only after the rains.

To remedy the damage and to provide against future contingencies, the following work was undertaken and completed during the succeeding working-season. The bridge-floor was renewed, and the east approach bank was raised 5 ft. and pitched, the line now rising up off the bridge to the summit of the bank. The spur-work was heightened in places and repaired, and the easternmost spur was continued in a northeasterly direction until it abutted on the river bank. [This final stage is shown in the accompanying figure.—Ed. Eng. News.] These remedies proved effectual during the rains of 1907; but the test is not convincing, inasmuch as the rains of that year gave no instance of long-continued heavy rainfall.

THE ESTABLISHMENT OF MUNICIPAL FORESTS by Pennsylvania cities, boroughs and first-class townships has been authorized by the legislature of that state. The bill giving this authorization was drawn and supported by the American Civic Association, and was discussed editorially in our issue of April 15. The Pennsylvania Legislature has also authorized the State Department of Forestry to raise seedlings and distribute them at cost.

THE DEPRECIATION OF WATER-WORKS is being studied by a committee of the American Water Works Association. The committee proposes to collect all the data it can, bearing upon the subject, particularly under the following heads:

Air Pumps.
Boilers—Fire Tube.
Boilers—Water Tube.
Buildings—Brick or Stone.
Buildings—Wooden.
Chimneys—Iron.
Chimneys—Brick
Chimneys—Tile or Concrete.
Condensers.
Conduits—Masonry.
Conduits—Iron.
Dams—Earth.
Dams—Masonry.
Filters—Gravity.
Filters—Pressure.
Foundations (for Boilers, Pumps, Towers, etc.)
Heaters—Feed Water.
Hydrants—Fire.
Meters.
Penstocks.
Pipe—Cast Iron.
Pipe—Wrought Iron.
Pipe—Steel.
Pipe—Galvanized.
Pipe—Wooden.
Piping in Power House.
Pumping Engines—Centrifugal.
Pumping Engines—Power.
Pumping Engines—Steam.
Pumps—Feed.
Rams—Hydraulic.
Reservoirs—Earth.
Reservoirs—Masonry.
Services—Wrought Iron.
Services—Lead.
Stand-Pipes.
Stokers.
Tanks Elevated—Iron or Steel.
Tanks Elevated—Wooden.
Valves—Gate.
Water-Wheels.
Wells.

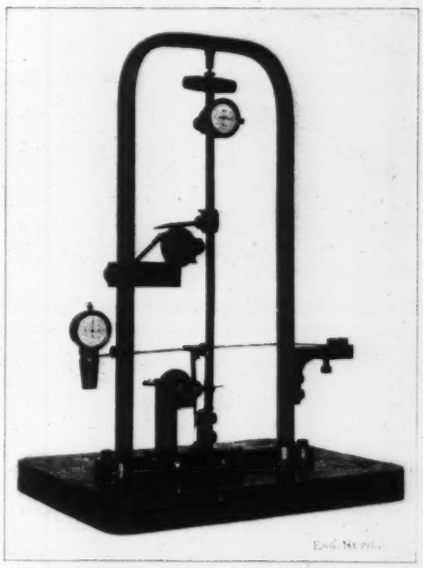
Cards have been prepared for making up records of depreciation. On one side provision is made for giving the name and location of the plant, the sender of the information, and the date of the report. On the other, spaces are given for filling in items as follows: Portion of work reported on; description; size or capacity; builder; installed; discontinued; life, years; why discontinued; condition when discontinued; value when discontinued; remarks. Circulars and cards outlining the proposed work of the committee may be obtained from Mr. William H. Bryan, Secretary Committee on Depreciation, Lincoln Trust Building, St. Louis, Mo. The names and addresses of the other members of the committee are as follows: Mr. John W. Alvord, Chairman, Hartford Building, Chicago, Ill.; Mr. D. W. Mead, First National Bank Building, Chicago, Ill.; Mr. Wynkoop Kierstead, Water Works Building, Kansas City, Mo.; Mr. James N. Hazelhurst, Candler Building, Atlanta, Ga.; and Mr. Leonard Metcalf, 14 Beacon St., Boston, Mass.

An Integrating Instrument for Roughness of Railway Track.

The track maintenance prizes which the Pennsylvania R. R. Co. awards each year to the maintenance employees on the smoothest-riding sections will in future be adjudged according to the showings of a novel instrument recently devised for this special purpose. The method hitherto used consisted in counting the number of spills of water from two glasses set on the window-sills of an inspection-car attached to one of the regular fast trains. The use of the new instrument will be a distinct improvement on this rough method, although the instrument itself does not give scientifically exact indications, but only an empirical approximate record.

The simple construction of the instrument may be explained by the help of the accompanying photographic view. A base-plate and a vertical frame set thereon support two flat steel reeds, one vertical and the other horizontal, clamped firmly at one end and bearing a weight at the other end. In the picture the horizontal reed is seen at about one-third the height of the frame, clamped to a bracket at the right and bearing at its left-hand end a weight on which is set a pedometer.

The vertical reed is in the middle of the frame, is clamped at the bottom, and carries



Integrating Instrument for Indicating Roughness of Track; Pennsylvania R. R. Co.

its weight and pedometer at the top; the plane of this reed is at right angles to the plane of the frame, and, the frame being set crossways of the car, the reed takes the transverse vibrations.

The pedometers give a record of the number of vibrations of the reeds, but take no account of amplitude of vibration. This latter is taken care of by integrating the total travel of a certain point on each reed, through a cyclometer whose stem carries a ratchet wheel driven by a toothed bar fastened to the reed. The cyclometer of the vertical reed is seen at mid-height of the frame, seated on a bracket of the frame, and actuated by a rack bar projecting to the left from the reed, in the plane of its vibrations. The other cyclometer is attached to the base, and is actuated by a rack projecting downward from the horizontal reed.

The instrument was designed by the Motive Power Department of the Pennsylvania R. R. Co. It is believed that the pedometer and cyclometer indications of the instrument, judged with due allowance for the speed of the train, and also judged in conjunction with the number of spills of water from a glass, will furnish a reliable estimate of the comparative riding qualities of different sections of track.

A Tripod for Brush Survey.

By E. M. DOUGLAS,* M. Am. Soc. C. E.

An elongated tripod which answers the same purpose and is somewhat more portable than the triangulation tower illustrated and described in Engineering News, issue of Feb. 11, is shown in Figs. 1 and 2. This device was adopted by the United States Geological Survey in carrying on topographic surveys in the cane brakes of Mississippi last summer. It consists of a tripod 8 ft. in length for supporting the plane-table board, and a light stool 3 ft. high on which the observer stands while at work. The tripod is of the split-leg style, with metal points. The side pieces of the legs are of hickory $1\frac{1}{4} \times \frac{1}{2}$ ins., and there are three cross-pieces to each leg, adding considerably to its stiffness.

To attach such tripod legs to an ordinary transit or level-tripod head, the side pieces are bowed in and a piece of wood 10 ins. long, and of suitable width, is fastened between them at the upper ends. This piece is bolted to the transit or level-tripod head as usual.

The tripod as well as the observer's platform can be increased somewhat in height and still be easily carried from station to station by one man. Such tripods have been found useful for running lines through vegetation of moderate height, since by their use much of the clearing away of underbrush has been avoided.

FIG. 1. ELONGATED TRIPOD FOR BRUSH SURVEYS. U. S. GEOLOGICAL SURVEY.

FIG. 2. USING AN ELONGATED TRIPOD ON PLANE-TABLE WORK IN A CANE BRAKE.

The Waterways of the United States: Actual Expenditures and Results to Navigation and Commerce.

By ALEXANDER H. WEBER,† M. Am. Soc. C. E.

This paper is presented in view of the interest manifested of late in the improvement of our waterways and the number of references thereto in the public press, some favoring and some opposing this class of work. Many of those offering contributions on this subject are optimistic in the extreme, prophesying the most extravagant and improbable benefits to follow large expenditures for these improvements, while it is not unusual to find those who claim that expenditures for these purposes are a useless waste of public funds resulting in no actual benefit either in the way of physical improvement or of increase in commerce. Some even believe that navigation is on the decline and that actual commerce handled by water has decreased. It is the purpose of this paper to show as clearly as possible the actual facts in the case as derived from a careful analysis of the records so far as they throw light upon this subject.

With a view to showing the total expenditures, the original and present depth, the change if any, the original and present commerce, and the corresponding increase or decrease, an examination has been made of every project upon which the Federal Government is now expending public funds, from the most expensive harbor of refuge or slackwater system of river improvement down to the shallow streams on which small expenditures are made in the removal of snags. A small number of the minor works now under way are not taken into consideration on account of their insignificance, the small expenditures involved, and the meager data regarding them. This number is but a small fraction of the whole, and therefore can be omitted without prejudice to the general results sought.

The latest information available on the subject under consideration is contained in the Annual Report of the Chief of Engineers for the fiscal year ending June 30, 1908. Earlier reports have also been consulted. Some of the works have been under way for many years, and the expenditures shown are in each case from the inception of the work to the close of the fiscal year 1908. While data regarding expenditures upon all works are available, early reports contain but meager information in regard to commerce. It would be desirable to compare the commerce at the time of the inception of the work with that of the present time, but this can not be done except in the case of a very small number of works of recent date. In the earlier days commercial statistics were not complete and in many cases were entirely absent or are now considered of doubtful value. In some instances the commerce was estimated in dollars, while in others it was given as so many packages, crates of merchandise, etc., the weight and value of which can not now be ascertained. It was not until about 1890 that particular attention was given to the collection of statistical data, and the items referred to below as original commerce are the averages of the first few years of reliable data, usually pertaining to the period from 1890 to 1895. The present commerce is an average of the last two or three years, except in a few instances where the growth has been steadily on the increase, in which cases the past year's commerce is given. The comparison therefore between original commerce and that of the present time covers a period of only about 15 years.

It is found that the total number of works upon which the United States Government is engaged is 495, and it is obvious that it would be impossible in this paper to give the details of each, although they have been worked out. In order, however, to show a comparison of results, the several kinds of works have been classified and those of similar character grouped together. The reason for this is that it would not be proper to combine the cost and results at an important commercial harbor having a costly jettied channel entrance, with those of a small inland stream; but a comparison of a number of the same class of improvements will give a very fair understanding of what has been accomplished. For this purpose the 495 improvements have been grouped into eight classes, and from an analysis of the details of the several groups the following results have been obtained:

CLASS I.—Harbors of refuge which are used solely for the protection of shipping and which show no results in regard to depth or commerce. Examples: Sandy Bay Harbor of Refuge, Mass., Delaware Breakwater, Mouth of Delaware River, Harbor Beach, Mich., Deep-water harbor at San Pedro, Cal. The number of these harbors is 24 and they have cost $14,312,000. Seven of them report having sheltered 10,775 vessels in 1907.

CLASS II.—Harbors which are used both for refuge and for commercial purposes. Examples: Rockland Harbor, Me.; Gloucester Harbor, Mass.; Block Island Harbor, R. I.; Marquette Harbor, Mich.; Oswego Harbor, N. Y. The number of works in this class is 24 and the amount expended on them $24,083,772. Thirteen show an increased depth ranging from 5 to 26 ft., aggregating 125 ft.; 11 either show no change or there is no information available in these cases. The total original commerce was 34,876,000 tons; the total present commerce is 50,801,000 tons, showing a net gain of 15,925,000 tons. Of the total number of improvements, 21 show a plus commerce amounting to 19,484,000 tons, and 3 a minus commerce amounting to 3,559,000 tons. Assuming Government money to be worth 3%, the total cost to the United States of this class of improvements is $722,500 annually, or, on the basis of the present commerce, 1.4 cts. per ton.

CLASS III.—Lake and coast commercial harbors, also tidal rivers. This is the most important class, as it includes not only the principal ports, but also a large number of tidal streams emptying into the seas, lakes and bays. Examples: Newburyport Harbor, Mass.; Boston Harbor, Mass.; Providence River, R. I.; Harlem River, N. Y.; New York Harbor, N. Y.; Delaware River, Potomac River, Savannah Harbor, Ga.; St. Johns River, Fla.; Galveston Harbor, Tex.; Ashland Harbor, Wis.; Ludington Harbor, Mich.; Oakland Harbor, Cal.; Humboldt Harbor, Cal.; Grays Harbor, Wash. The number included in this class is 265, on which the expenditures have been $172,707,900. Of these, 240 show an increase in depth ranging from 1 to 23 ft. and amounting to a total of 1,558 ft. Twenty-five report no change, or there is no information on the subject. The total original commerce was 167,465,000 tons; the present commerce, 353,585,700 tons, showing a net gain of 186,120,700 tons. Of the total number, 175 show an increase in commerce amounting to 199,111,500 tons, and 68 show a decrease in commerce of 12,993,800 tons. At 3%, the total annual cost to the United States is $5,181,237, or, on the basis of the present commerce, 1.5 cts. per ton.

CLASS IV.—Rivers under improvement by regulation or by locks and dams. Examples: Merrimac River, Mass.; Cape Fear River above Wilmington, N. C.; Alabama River, Ala.; Black Warrior River, Ala.; Arkansas River, Mississippi River, Monongahela River, W. Va., and Pa.; Kanawha River, W. Va.; Sacramento River, Cal. The expenditures under this class include the total amount that has been expended by the Mississippi River Commission, over $53,000,000, and also $23,000,000 provided by continuing appropriations for the operation and maintenance of the several locks and dams and for continuing snagging. The fact is well known that a large part of the funds used on the lower Mississippi River has been for the construction of levees,

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the benefits from which are far-reaching and not confined to commerce or navigation. The total number in this class is 76, and the expenditures on them amount to $204,718,500. Thirty show an increase in depth ranging from 1 to 8 ft., aggregating 101 ft.; 46 either show no change or the data are not available. It may be stated as a fact, however, that in many instances where no increase throughout has been reported for this class of work, there has been marked improvement on certain stretches covered by the actual work done, the lack of favorable results on the project as a whole being due to the incomplete condition of the work. Total original commerce of Class IV., 49,155,000 tons; total present commerce, 64,374,000 tons; net gain, 15,219,000 tons. Forty-three show a plus commerce amounting to 25,636,000 tons; 22 show a minus commerce amounting to 9,817,000 tons. The annual cost to the United States at 3% is $6,141,555, or 9.5 cts. per ton on the basis of the present commerce.

CLASS V.—Interior shallow streams under inexpensive improvement such as snagging, removal of obstructions, a small amount of dredging on shoals, etc., designed to make existing depths available rather than to produce any appreciable improvement in physical conditions. The work is intended only to keep the rivers in a navigable condition. Usually these streams have a low water depth of from 1 to 3 ft. Examples: Little Pedee River, S. C.; Upper Tombigbee, Ala.; Yazoo River, Miss.; St. Francis River, Ark.; Snake River, Ore., and Wash. Number of works, 67; amount expended, $7,200,900; no increase or decrease in depth. Total original commerce, 3,161,000 tons; total present commerce, 5,019,000 tons; net gain, 1,858,000 tons. Thirty-three show a plus commerce amounting to 2,517,000 tons, and 16 show a minus commerce amounting to 659,000 tons. Annual cost to the United States, $216,000, or 4.3 cts. per ton.

CLASS VI.—Inland waterways and canals. Examples: Inland waterway from Savannah to Fernandina; inland waterway from Franklin to Mermentau, Illinois and Mississippi Canal. Number of works, 7; amount expended, $9,956,600. Three show an increased depth ranging from 4 to 7 ft., aggregating 15 ft.; 4 are deficient in data. Total original commerce, 1,331,000 tons; total present commerce, 3,272,000 tons; net gain, 2,941,000 tons. Three show a plus commerce amounting to 2,203,000 tons, and 2 a minus commerce amounting to 262,000 tons. Annual cost to the United States, $298,698, or 9.1 cts. per ton.

CLASS VII.—Special work, auxiliary channels, removal of rocks, etc., affecting main through navigation only indirectly and which show no effect upon commerce. Examples: Removal of rocks at Hell Gate, N. Y.; closing Pass a Loutre, Mississippi River, La.; Harbor at Vicksburg, Miss.; Harbor at Pittsburg, Pa. Number, 12; expenditures, $14,602,000. These show no commercial results.

CLASS VIII.—Channels connecting the Great Lakes. While the number of works falling under this head is small, they are grouped together and treated separately on account of their great importance and the weight they would carry if included in any other class. They consist of St. Mary's Canal, Hay Lake and Neebish Channels, Detroit River, St. Clair Flats Canal, and connecting channels. Number of works, 5; amount expended, $25,198,000. All show an increase in depth ranging from 7 to 16 ft. Original commerce, 25,000,000 tons; present commerce, about 75,000,000 tons, an increase of 50,000,00 tons. Annual cost to the United States at 3%, $755,940, or just 1 ct. per ton.

Summarizing the above, it is found that the total expenditures on the 495 projects amount to $471,199,000, total original commerce, 281,760,000 tons, total present commerce, 591,977,700 tons, a gain of 340,217,700 tons, number of projects showing an increase in commerce 217, number showing a decline in commerce 111, excess in number showing increase over decrease 106, annual cost to the United States at 3%, $14,135,970, or 2.4 cts. per ton. Of the 374 projects designed ultimately to produce increased depth, 288 show an actual increase ranging at the different localities from 1 to 26 ft., and aggregating 1,814 ft. The remaining 86 show either no appreciable results or information is lacking, the latter applying in the majority of cases, although in not a few instances advantageous results are shown for short distances covered by works only partially completed, actual benefits not being expected until the work has been farther advanced.

The total of all expenditures on rivers and harbors since the inauguration of the work nearly a century ago is about $511,000,000. The difference between this sum and the one reported as having been expended on existing projects represents the amount expended on a few unimportant existing improvements not taken into consideration on account of meager data concerning their commerce and physical condition, and a number of obsolete projects of earlier days which have long since been discontinued.

The question of the total actual amount of existing commerce handled by water is an interesting one and is difficult of solution. As stated above, 591,977,700 tons are reported as applying to the localities upon which expenditures are being made. Some of this is necessarily reported in duplicate, and some of it even in triplicate or quadruplicate. The explanation of this is that each work reports the commerce affected by or using it. As an extreme example, the tonnage in iron ore from Lake Superior ports is first credited to the locality from which it is shipped, then to the St. Mary's Canal, then to the Detroit River, and finally to the Lake Erie Harbor where it is transferred to smelter or rail. Again, coastwise traffic is usually reported in duplicate, first at this point of shipment and again at the port of destination. The exception to the general rule is in the case of foreign commerce and that pertaining to a few rivers where the traffic is local. An effort has been made to ascertain the amount of the actual waterborne commerce in the following manner and it is believed the results approximate the truth.

The total commerce reported for the several harbors and connecting waterways of the Great Lakes is found to be 268,963,000 tons, including that passing through St. Mary's Canal, and Detroit River which amounts to 114,926,000 tons. Deducting the latter amount, we have the actual commerce passing from one port to another, 154,037,000 tons, and one-half of this sum or 76,968,500 tons represents the actual existing tonnage of the lakes. To this has been added the foreign commerce of our seaports which amounts to about 35,000,000 tons, and one-half the coastwise and river traffic which amounts to about 288,000,000 tons and which is reported in duplicate. The river traffic is the most uncertain of definite determination for the reason that as already stated some of it is local and reported but once, while in cases like the Tennessee River it is reported more than once and a part of it enters into the amount reported for the Ohio River. The same may be said of many of the tributaries of the Mississippi, a part of the commerce at least of most of these streams being credited to the river in which it originates and also to the river in which it finds its destination. The amount of this commerce is not large when compared with the whole, and the method adopted is believed to offer the best and at least approximate results. From this method of calculation, the total actual existing waterborne commerce of the United States is found to be approximately 256,000,000 tons per annum. On the basis of this actual commerce, the cost per ton to the United States is 5.5 cts., and if we consider the total outlay on all improvements since the inception of the work a century ago, the cost is 6 cts. per ton. It would be interesting to know what saving this six-cent expenditure has effected. Any estimate would be little more than a guess and could not be verified. The writer has seen it stated in connection with certain localities that the saving due to better navigation facilities has been at least $1.00 per ton.

Appertaining to the lack of favorable results in some instances, it is frequently noted in the reports, particularly those prior to about 1880, that appropriations were very irregular and not commensurate with the character of the work to be performed. Even after the period mentioned, funds were in many instances inadequate, and it appears that the work was necessarily carried on in a desultory manner not calculated to produce the best or most economical results. An important item of legislation on the subject of the improvement of our waterways is contained in the River and Harbor Act of 1902, which provides that all projects for the improvement of rivers and harbors shall be referred to a technical board of review. Since that date practically no work has been undertaken or authorized without careful consideration of its merits both from a commercial as well as an engineering point of view.

With regard to the number of improvements which show a decrease in commerce it seems proper to call attention to the obvious reason for this in at least some cases. These works were undertaken years ago before the localities had the advantage of railroad facilities and the only means of communication was by water which was resorted to from necessity, although the water route may not have followed the natural line of trade, and navigation was difficult and expensive. It was natural under these circumstances that with the advent of the railroads much of the commerce should be diverted. It should not be forgotten, either, that in the early days when light draft river craft carried freight and passengers long distances, prices were charged accordingly, and these were very much higher than the rail rates which followed. The fact is well established that as a general proposition railroads can not compete successfully with first-class water routes. This is not true, however, in the case of inferior waterways where distances are great and the capacity of the stream limits its use to small craft. Again, the very fact of the building of railroads often diverts the trend of commerce and causes commercial centers and traffic routes to change, and this undoubtedly accounts for the decline in trade in certain localities. It is, therefore, not a matter of surprise that in the general development and building up of our country some of the early established routes should show a decline in commerce in favor of others more advantageously located. This is but an incident to be expected in the general progress shown by the figures above.

Fundamental Principles of Sewage Purification on Land.

By RUDOLPH HERING,* M. Am. Soc. C. E.

The building of sewage purification works was started in Europe, where, without question, the largest number of such works have been constructed. Whatever has been done in our country in the way of experiment, study and operating plants, creditable and valuable as it is for our somewhat different conditions, we can, nevertheless, appreciate our own difficulties and even intricacies better by taking into consideration the extensive experiences abroad.

This fact was fully appreciated by the writer when he was making a special inspection of European works in 1905, as was the further fact that there were still great differences of opinion regarding the value of methods and practices. The reason was obvious: the subject was not yet sufficiently well understood and much speculation and belief still prevailed. Since then both Europe and America have made progress, but even now there is not yet a universally accepted scientific theory to form the basis of design for modern plants, as there is for the older intermittent sand filters.

A re-examination of the European works last summer showed many advances, not only in theory, but also in the coordination of data, illustrated, for instance, in the excellent English report of the Royal Sewage Commission. Still, there is lacking, also, in Dr. Dunbar's excellent work on sewage treatment, the best which has yet appeared, a complete exposition of the subject, embodying sufficient information by which an engineer can design purification works with the same confidence and economy in detail as he can design a bridge, a machine, or even a slow-

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sand water filter. There is lacking also a sufficiently extensive experience and experiments, to show the correct relation of all of the several elements which make up the whole process of sewage purification, so that it can be applied to all of the different conditions presented in concrete cases. Consequently, there still are a number of experiment stations actively in pursuit of this subject, both in Europe and here, and it may not be long before all the desired bases are developed for safe and economical design.

For about thirty years the subject of sewage purification has presented itself to the writer in the pursuit of his professional work, and it is but natural that he should have acquainted himself with every phase of the subject coming to his notice, particularly during his late trip to Europe. This paper will briefly review the more important of these phases because it is the writer's belief that the conclusions to be drawn from them bring us quite closely to the goal that we are seeking, and clearly point out the directions where, within perhaps a short time, the wanting facts may be found.

Early in the 70's the writer was employed to make some simple calculations to determine the superficial areas of a grain of strychnine when triturated to various degrees of fineness, so as to throw some light, if possible, on the surface action of triturated medicines within our bodies. The only fact remembered is the practicability of getting a surface of ten feet square in a powder weighing but a grain. This became of special interest in the 80's, when the purification of water and sewage by percolation through sand beds was coming to the fore.

A little later, Mr. B. H. Coffey, in discussing at the Philadelphia Engineers' Club the purifying effect of sand filtration, emphasized the large surface of sand grains that are available for action, viz.: 1 cu. in. of sand grains, 0.01-in. in diameter, presents a surface of 314 sq. ins. to the percolating water.

In 1880 the writer was abroad studying sewerage systems for our National Board of Health. The Massachusetts State Board of Health had published, in 1879, an excellent report by Dr. Folsom, on an inspection made by him of the sewage disposal works in Europe. Although the writer was directed to report only upon sewer design and construction, chiefly as to the relative merits of the combined and separate systems of collection, yet he inspected also the most interesting disposal works and called upon the chief workers in this field. It was then that he first met Bailey Denton, and visited his sewage purification plant at Merthyr Tydfil, which he designed and built about 1870. He called the system "Intermittent Downward Filtration," and maintained that one acre of sandy soil would continuously purify sewage from 1,000 persons. Mr. Denton was a drainage engineer and had observed that strongly manured fields yielded a clear and pure effluent water from the sub-drains, which fact had suggested to him the application to sewage purification. He was emphatic in his insistence upon "free draining soil" and upon "intermittency" of application by the advice of Sir Edward Frankland, because, as he expressed himself, "the soil needs to breathe." He presumably knew nothing about bacterial action, nor just how the sewage was being purified. The effluent looked like spring water and was drunk by cattle in preference to the river water.

This inspection of what was the first intermittent sewage purification plant ever built, was supplemented a few months later by a visit to Dr. Alexander Müller, City Chemist of Berlin, who is now known as the first one who recognized the office of bacteria in sewage purification. He showed with enthusiasm, at his laboratory, the effect of micro-organisms, as he then called the bacteria, on feces and urine. He recognized their office, not only in sewage purification, but in the conversion of manure into "nourishing liquids" to be absorbed by plants, on which he wrote one or two articles in agricultural papers. Dr. Müller maintained that excreta were completely converted into matter harmless to us and useful to plants, by these minute organisms, and that, therefore, they should be separately collected and used for agricultural purposes.

It was not until some years later, when bacteriology had been developed as a science, that the writer brought the ideas of Bailey Denton and Dr. Müller together, so as to recognize the probably important office of bacteria at Merthyr Tydfil. The classical work of Frankland, and the investigations of Schloessing, Müntz and Warrington had demonstrated the connection, and in 1890, our Massachusetts State Board of Health, by its elaborate investigations, had furnished the data by which an engineer could design an intermittent sand-filtration plant, so as effectually to utilize the work of the bacteria, and safely guarantee its results.

These investigations, however, were mostly confined to sand filtration. It was found that in some localities sand filtration was too expensive, particularly in England, where sand is scarce.

The Massachusetts State Board of Health had shown by a laboratory experiment in a small tank that sewage could be purified at greater rates, and therefore more economically, in filters made of stones of hazel-nut size, instead of sand, provided that the sewage was sprinkled upon the sand. Mr. J. Corbett later constructed the Salford Works upon this suggestion. It was demonstrated in England and France that the bacterial slime covering the stone surface contributed to the sewage purification. It was shown by Scott-Moncrieff in England, that an abundant aeration of sewage suitably applied greatly assisted the purification.

It was further shown in England, in 1892, through the suggestions of Sir Alexander Binnie, by Santo Crimp and Dibdin, that sewage in contact with stone surfaces for a few hours was purified sufficiently to be non-putrescent, when leaving the same, therefore proving that to render sewage inoffensive much less land was required by this method than by sand filtration.

More economical methods of sewage purifications were, therefore, coming into view.

The writer will now analyze the subject along the paths just mentioned, because during his visit to Europe, last year, such analysis seemed specially helpful to a better understanding of the conditions observed both here and abroad.

In treating the subject, particularly in Europe, attention had at first been given almost exclusively to its chemical and bacteriological aspects, and comparatively little was given to the physical conditions controlling the same. It is now recognized that the latter are equally important.

Bacterial Surface.

With the above results and conclusions before our profession, the writer remembered his computations in early life regarding surface action of finely divided matter. It was now established that bacteria were instrumental in purifying sewage and that they adhered to, and operated, upon firm surfaces. The larger the surface, the more bacteria could operate. Therefore, the smaller the stones of the bed, correspondingly increasing the surfaces, the better would be the effluent sewage. Sand of the same depth unquestionably produces a better effluent than larger stones, assuming for the present all other factors except the superficial stone area to be equal.

This area since the trip to Europe in 1905, the writer has been accustomed to call bacterial surface, to indicate what seems to be one of the essential factors in the process of sewage purification, one which had not been sufficiently studied or appreciated, and one which seemed to explain certain actions of filters not yet clearly understood.

Experiments both in Europe and here, proved that, as between coke, broken stone and gravel of the same depth and size of grain, the coke always gave the best and the gravel the least good effluent. The character of the mineral generally made no difference, except slag or cinder, when sulphur sometimes contained therein, acted detrimentally as a germicide.

There is a large difference in these materials as to their bacterial surface, and yet it is almost impossible to measure it by any practical means. Some microscopical examinations and approximate theoretical assumptions and computations, led the writer provisionally to adopt certain proportions, simply to facilitate an explanation of the importance of knowing the area occupied by the working bacteria. Assuming the surface of a sphere of glass as unity, he then took the surface of a pebble of gravel of the same average diameter as being about 1½, of broken stone about 2, and of slag about 2½ and over. In other words, slag of the same size as gravel, will give $\frac{2\frac{1}{2}}{1\frac{1}{2}} = \frac{5}{3}$, or nearly twice the bacterial surface, and other things being equal, will be almost twice as efficient a sewage purifier. The fact that a slimy coating covers and conceals many of the minute irregularities of the surface, affects this conclusion only slightly, because, when the slime becomes very thick, the efficiency of the bed decreases, and it is said, "needs a rest." The general form of a stone of irregular shape will not be greatly changed by a film which has not become too thick to be of the best service.

Under this heading it must also be said that the bacterial film itself has a large internal surface development. Dunbar compares it to starch, of which one cubic millimeter, when dry, is capable of developing, when wet, an internal superficies of two million square millimeters. Bacteria are undoubtedly capable of utilizing a very large part of this internal area. But the effect is simply a multiple of what is to be expected from the bacterial surface surrounding each individual grain, and applies to all materials alike.

It seems that the extent of bacterial surface is one of the directions in which more exact practical information is needed, and it is to be hoped that some of the experiment stations may furnish the same. Its economic importance is evident. If, at the same expense, we can provide rougher stone, with a greater bacterial surface, we can correspondingly reduce the quantity of stone and the cost of the purification works. It will then become practicable, still assuming that all other factors are the same, to establish the number of square feet of ripe bacterial surface, required to purify to a given degree the average sewage per person per day, and to determine the depth, and, therefore, the quantity of the available material required to obtain such a degree. It will become practicable to state, not only how many square feet of bacterial surface are required to obtain the high degree of purity resulting from intermittent sand filtration, but also how many square feet are required in contact beds and sprinkling filters to obtain merely a non-putrescence of the effluent. In short, given a desired degree of purification, a filter to produce it can be economically designed.

To illustrate what has just been set forth, I have tabulated data from three European sprinkling filters, viz.: Hanley, Eng., which gives the best effluent; Birmingham, Eng., which gives a fair, but less good effluent, and Wilmersdorf, a suburb of Berlin, which gives the least good of the three effluents. The writer, of course, is conscious of the value of preparatory treatment, and that the sewage of Birmingham, and particularly Hanley, have a better preparation before they reach the filters, than Wilmersdorf. But that does not affect the present conclusion. The larger the required bacterial area, the smaller must be the stone for the same depth of filter, and therefore, the greater is the necessity

COMPARATIVE DATA ON THREE SEWAGE PURIFICATION WORKS.

	Average diam. in ins. of medium.	Superficial value of medium.	Bacterial surface in sq. ft. per cu. ft.	Depth of bed in ft.	U. S. gals. applied per sq. ft. of bed per day.	Sq. ft. of bacterial surface purifying 1 U. S. gal. per day.	Sq. ft. of bacterial surface per person.	Character of effluent
Hanley (Saggers)	⅝	1½	135	6	27.5	24.5	710	Excellent.
Birmingham (slag & granite)	1¾	1¾	60	6	29.8	14.1	367	Fair.
Wilmersdorf (coke)	5	2½	25	8.2	34.4	6.0	160	Tolerable.

for a good preparation in the removal of suspended matter to prevent clogging.

The accompanying table shows the average diameter of the stones, their estimated bacterial surfaces, the quantity of sewage applied per square foot of bed per day, which is practically the same in all three cases, and the square feet of bacterial surface per person. It is seen that Hanley gives a surface of 710 sq. ft. per person, with an excellent effluent, Birmingham has 367 sq. ft. with a fair effluent, and Wilmersdorf has only 160 sq. ft. with but a tolerable effluent.

It is not pretended that the superficial values of the medium are more than a very rough approximation. Let us, for a moment, assume their correctness, so as to illustrate an example, and assume that we desire a degree of purity that would be yielded by 500 sq. ft. of bacterial surface per person, and that for good reasons we desire to use hard coke and a depth of filter of not more than six feet. We would then compute the average diameter of grain of the medium required to give the desired degree of purity, to be about two inches, provided no other elements than those of bacterial surface are considered, and that the preliminary preparation corresponds to what is necessary for such a diameter of grain, and for the corresponding time of percolation.

A sand filter would have a much greater bacterial surface per person than Hanley, and give a still better effluent. A contact bed to give the same non-putrescent effluent as sprinkling filters would require a greater bacterial surface, because there is not an equally effective means offered for oxidation. Sprinkling filters have a constant circulation of air through the interstitial spaces, while in contact beds the aeration is confined to the period during which the sewage is drained out. Therefore, contact beds, to give an equally good effluent, require a greater bacterial surface than sprinkling filters.

It may be said that if the suggested effect of the different superficial values of the three kinds of medium is ignored, the Hanley bacterial surface would still be greater and the Wilmersdorf bacterial surface still be less than the Birmingham surface. While this happens to be true in these individual cases, it presents no argument against the general principle already stated.

Liquidity.

After giving the bacteria a sufficiently large field upon which to operate, we must give them also the best conditions for activity and propagation. Such are a liquid state of the sewage, or practical freedom from suspended matter, a sufficient supply of air, a sufficient length of time for oxidation and a proper temperature. The purification of sewage by oxidation can take place only if the substance is in liquid form, and perhaps in semi-liquid, or what is now often called colloid form. In order to get solid sewage matter into this form, it must either be dissolved, or a hydrolysis or bacteriolysis must have taken place, which is an anaerobic fermentation or putrefaction. By this process, organic matter is transformed into simpler forms, which subsequently are more readily "burnt up" by the air. Anaerobic liquefaction may take place very rapidly. It may do this under conditions not necessarily apparent either by any bad odor, or otherwise. It goes on inside of a clot of fecal or other animal matter, or in vegetable matter exposed to air only on the outside. Rotting fruit is an easily observed case. Sewage, when comparatively fresh, has these disintegrating changes going on perhaps to a considerable extent. Hydrolytic changes are also accomplished by enzymes, which are the products of, but not themselves, living animal and vegetable organisms.

The food in our bodies must be in a liquid state to be absorbed and converted into blood, for which a complete change of the physical condition of the food is necessary. It is liquefied in part by the gastric juice and other secretions, and in part by the anaerobic bacteria which by the million inhabit our intestines.

That the aerobic bacteria on the surface of the stones of the filter liquefy some of the solid matter of sewage, is probable, but has not yet been demonstrated. Practical results, however, are so plentiful to indicate the great importance of removing as much of the suspended solid matter as possible before discharge upon the filter, that liquefaction in the filter itself is a minor factor if it occurs at all.

Sewage in its raw state, containing much finely divided suspended matter, can be applied only in small quantities, compared with sewage that has been settled, clarified or screened. In fact, the allowable rate of application varies almost in a direct ratio with the amount of suspended matter which the sewage carries.

The oxidation, or mineralization of fluids, dissolved solids, or colloid matter when accomplished by bacteria, necessitates a liquid or semi-liquid condition before the bacteria can utilize it. Therefore, we are compelled to supply the sewage as nearly as practicable in liquid form. In this form it can surround the grains as a thin and fairly uniform film, flowing slowing downward over the slimy bacterial surface and permitting all of the sewage to have the greatest practicable contact with it.

Any putrescible solid matter that enters the bed, and is not at once liquefied either deposits and tends to clog it, or it passes through and leaves the filter before it can be properly reduced. A number of the recorded failures of filters were due to the fact that the sewage contained too large an amount of putrescible suspended matter when it reached the filters. The failure will be due both to the insufficient oxidation within the short available time, as well as to the stoppage of the interstices by the fibrous matter bridging them.

One of the essential conditions of a purification plant is, therefore, a proper preparation of the sewage before it is discharged upon the filter, so as to remove from it as much of the suspended matter as possible.

This conclusion is not less applicable to sand filters than to coarse-grained filters. A much greater yield per acre is secured in both cases. There is a practical difference between the two, however, which does not make the high grade preparation for a sand filter equally imperative. The clogging of a sand filter can be readily removed by the simple process of surface raking, but the clogging of a coarse-grained filter means the entire removal of the stone for cleaning, as recently done in Manchester, Eng.

Air Supply.

The third essential element in the final stage of sewage purification is an abundant supply of air.

One of the best established facts in sewage purification is that the last stage of transformation of dead organic matter is an oxidation, by which all dissolved organic matter is mineralized.

The oxygen for this purpose is practically all furnished by the air, a sufficient quantity of which must, therefore, be brought in contact with the dissolved sewage matter. Dr. Rideal gives the amount of oxygen required to nitrify English sewage as that which is contained in about half its volume of air; for average American sewage we might say that it was equal to one-quarter of its volume of air. This being a minimum amount, and realizing that irregularities in the distribution may reduce the effect by one-half, or even three-quarters; and also in cases where aeration is not expensive, it is always well to supply an abundance of air to pass over the thin layers of liquid sewage.

Waring's air pumping at Willow Grove, Pa., was very successful in sewage purification, but was more expensive than warranted. Sack's pumping air and ammonia from the manure pits of his barn near Leipzig into his fields, several feet below the surface, materially increased the yield of crops, but also here the expense was not justified.

It is held by some that aeration beyond a given amount has no useful effect. Mr. Watson, at Birmingham, found it to be so. On the other hand, Scott-Moncrieff and some German investigators found decided benefit by supplying a surplus of air. The English filter units when raised above the ground, and given open sides, so that the wind can blow through, and those at Wilmersdorf near Berlin, where similar filter units have air pipes bedded within, all show that benefit is obtained from ample and free ventilation.

At Birmingham it is necessary to rest the filters about 10% of the time for the purpose of letting the accumulated bacterial slimy growth dry and shrink, and thus increase the interstitial space, so that the best efficiency may be obtained.

The beneficial effect of ample ventilation was never more strongly impressed upon the writer than when he saw the evidence in favor of it for the first time. Mr. E. C. Clarke, M. Am. Soc. C. E., when building some of the first sewers of the main drainage system of Boston, showed two house connection pipes that had been cut off and were to be intercepted by the sewer. One had the usual main trap at the house, and that part of the pipe which was below the trap, was coated with a layer of slime and vegetable growth, perhaps 1 in. thick. The other had no trap, and had been ventilating the old sewer now being displaced. This old house pipe, although conveying practically the same quality and quantity of house sewage, had almost a clean surface due to the constant air current which passed through it, and held the growths down to a minimum.

The writer cannot suppress the thought that the necessity for letting the bacterial slime diminish at Birmingham by resting the filters, would perhaps not arise if more ample air current were allowed to pass through the beds. Similar indications are found also elsewhere. Certainly, more definite and consistent information than is now available on this point would be valuable, and it is hoped that it may be obtained at some of the experiment stations.

Air is supplied to sand and contact beds and to sprinkling filters by the descending sewage percolating through them. Where sprinkling filters are built above the ground, a further aeration is produced by the wind striking the sides. Wind blowing over the beds has a certain ventilating effect, but only if there is a free opening elsewhere, and when by pressure or suction a current can be established. The freer the air supply, the quicker is the oxidation. The larger the pores, the freer is the circulation. We have, therefore, an antagonism between the extent of bacterial surface and the freer air supply, because the larger the one, the smaller is the other. Experience must yet determine the minimum air supply, together with the minimum bacterial surface that will be advisable to obtain the most satisfactory results.

A cheap and effective method of aeration is obtained by the use of ventilating hoods held towards the wind by vanes, and discharging the air into drains, which should be trapped and sealed so the air will rise upwards through the filter. In sand filters this method is not effective, because of the smallness and unevenness of the interstitial channels, while in broken stone these channels are large and free. As the rate of percolation is much slower in sand filters than in broken stone filters, such assistance in supplying a sufficient quantity of air is not as necessary in the former as in the latter.

Air forced into the underdrains of stone filters has less resistance when escaping vertically to the surface within 6 or 8 ft., than when striking against the side of the unit. It is, therefore, likely to be dispersed more uniformly through the mass of the stone and will be more effective. A calculation based on Dr. Rideal's conclusion indicates that even from slight winds there is a material benefit to be gained when the air is conducted into the underdrains. Along this line also some carefully ascertained practical data on a large scale are desirable.

The air supplied to the sewage by absorption during the time when it is sprinkled upon stone beds from jets or nozzles is slight. Dr. Rideal says that to convert the nitrogen of sewage into nitrates, about one-half gallon of air must be continuously supplied for every gallon of English sewage. "This explains," he says, "the comparative failure and frequent collapse of filter beds in large masses," by having an insufficient

air supply. Dr. Fowler calls attention to the fact that exposure to air is only effected when it is exposed in shallow layers and for a considerable length of time, and that aeration by any system of spraying would not at all be adequate, because one gallon of water, even saturated with oxygen, contains only about one-fifteenth of the required amount.

The absorption would be proportional to the surface exposed to air, and proportional to the time of such exposure. The fine dust-like spray from the sprinklers of Europe, no doubt, allows of more air absorption than our thicker streams for the same quantity of sewage. The time of exposure, while sprinkling, is but a few seconds, but it is minutes or hours before sewage percolates through a filter, and the avidity of absorption on first exposure is satisfied as well in the interstices of the bed, particularly when the stones are large, as in the open air.

Length of Time of Percolation.

It was mentioned above that there existed a fixed relation between the amount of liquid sewage per person, and the bacterial surface which would give it any desired degree of oxidation and, therefore, of purity. There exists a simliar relation between that amount and the time during which the sewage is exposed to bacterial action.

While experience has given us some data regarding the necessary time, the information is still insufficient in several respects. In the first place, the time which is necessary depends upon the character of the sewage, as to whether or not it is in a state to be easily decomposed; and secondly, it depends upon the temperature, to be presently mentioned.

The character of the sewage affects the time element quite materially. As there is a fairly definite relation between the required time for a certain quantity of sewage to percolate through filters with different sizes of grain, it is evident that the available time required for a given filter will largely determine the character and extent of preparatory treatment which is imperatively required for that filter before the sewage reaches it. The preparatory treatment will be discussed in a later paper.

Dunbar gives some important data regarding the time of percolation, and the conversion into a purified effluent. For a depth of stone of one meter, ten minutes were sufficient; for a depth of one-half meter, five minutes sufficed; for a depth of 20 cms. 26 secs; and for a depth of only 10 cms., or 4 ins., 12 secs. were enough to allow a purified sewage to appear. We have other data which are confirmative of a purification within a very few minutes, understanding that this purification here implied means merely a non-putrescent effluent.

Dunbar explains this rapid purification by saying that the dissolved organic matter is extracted by the bacterial film, held back by it, and not until during the following period of rest is it decomposed and oxidized. He bases this explanation on his theory of absorption of the dissolved organic matter and also of oxygen in sufficient quantity to oxidize it. He gives information proving that the process creates a vacuum due to the oxygen absorbed, as the anaerobic process causes a plenum and expansive pressure due to the evolution of hydrogen compounds. While being absorbed decomposition takes place.

There cannot be any doubt but that the dissolved organic matter is in contact with the bacterial film, and that oxygen is withdrawn from the air during the process. But there does not appear to be evidence to prove that the dissolved organic matter is held back until "the following period of rest" before it is oxidized, unless this time be limited to a few minutes. Dunbar apparently does not give data as to the actual time required for the conversion.

Oxidation, no doubt, takes place continuously within the pores of the filter if an available excess of air is present. It does not stop while the sewage is percolating, unless the pores are completely filled by the liquid. The Birmingham spray acts continuously for long periods, and purification is going on just as continuously.

The organic matter in solution passes over and is absorbed by the bacterial film. The amount thus absorbed becomes greater as the thickness of the film increases, to a certain limit. The structure of the film, according to Dunbar, resembles starch, as already mentioned, and can therefore expose the liquid to a very large internal surface of action. As the film becomes thicker, the bacteria becomes more numerous, and the action becomes more intense, thus ripening the filter.

In the same measure as the absorption goes on, there must be a corresponding giving-off of the nitrified liquid, or other products of bacterial activity. The two processes must balance each other. Absorption cannot continue perpetually, without a corresponding excretion. The bacterial flora, by their avidity for oxygen, cause the excessive absorption beyond what would take place if the material were sterilized, and the absorption of oxygen ceases when sterilization is complete, or when the supply of oxygen is exhausted.

If we assume a time element as being necessary to accomplish this result, we must necessarily have a corresponding storage of the liquid in the filter pores, just as we need basins to hold back sewage for sedimentation or septic action. This storage in the filter bodies must, however, of necessity, be considerably less than the space occupied by the interstitial water, and perhaps not more than the non-drainable water on account of the lack of storage space. It is, therefore, difficult to see how any storage by absorption in a sprinkling filter could be maintained for a long time. Nor does it, from other indications, appear necessary to assume a long period of storage, if the filter is ripe, if the bacterial surface is sufficiently large, and if the applied sewage is a liquid. Suspended matter certainly requires a longer time for conversion, but a liquid can be at once attacked and altered.

If the sewage is not in a liquid state, this short time will not suffice to oxidize it. If the filter consists of coarse-grained material, any solid suspended matter not held back by adhesion may pass through unoxidized, and either escape into a water-course in this condition, or require an after treatment. In a sand filter the solid suspended matter is strained out and held back at the surface where it can readily remain days, weeks and months, until the complete decomposition takes place, which circumstance is one of the practical advantages of sand filtration.

More information than we now have is needed to give with fair exactness the time required for different degrees of purification of sewage carrying a practical minimum of suspended matter, from a few minutes in a sprinkling filter giving a non-putrescible effluent to perhaps days in a fine-sand filter giving an effluent free from bacteria and one which is drinkable.

The speed at which water percolates through a filter depends upon two things: First, upon the friction which increases as the size of grain and interstice becomes less, and secondly, upon the amount of sewage discharged upon the filter.

Last year there was published, as a paper in the Proceedings of the Institution of Civil Engineers, a valuable contribution on this subject by William Clifford, Assoc. M. Inst. C. E., entitled "On Percolation Beds."

Mr. Clifford set out to ascertain by certain experiments the time of percolation through clean material of various sizes, from ¼-in. to 1-in. in diameter. He gives a formula which may be written

$$t = \frac{I}{c\,R},$$

in which t = time of percolation; I = interstitial water; R = rate of sprinkling, and c = a constant, 0.031 for Imperial gallons.

Mr. Clifford finds that a bed of fine breeze ⅜ to ½-in. diameter of grain, 6 ft. deep and sprinkled at the rate 200 Imp. gals. per sq. yd. per day, allows about 16 hours for contact. Coarse gravel 1-in. to ¾-in. diameter of grain, of the same depth and rate allows only about 11 minutes for contact. He assumes for English sewage 100 minutes contact, as giving a good non-putrescible effluent. The time of percolation was found to vary directly as the amount of interstitial water, i. e., the greater the rate, the greater is the amount of water in motion. Large doses at long intervals were found to give less time for percolation than small intermittent doses, or light continuous spray with uniform distribution; and further, the product of time and rate of percolation for any one grade of material was found to be practically constant.

We must also record the further fact that the degree of sewage concentration has an effect upon the necessary time which must be allowed for percolation. A dilute sewage requires less time than a concentrated one, and the evidence is conclusive that the necessary time varies more nearly per capita of population contributing sewage to be oxidized than per quantity of water which carries the polluting matter as sewage. It would, therefore, be more intelligible to tabulate the respective information per capita than per quantity of sewage.

Temperature.

As the process of purification is an organic one, it is necessary to provide the most favorable conditions for bacterial action to take place. The temperature must, therefore, be as much above the freezing point as practicable. Results have shown, both in Europe and here, that below 40° F., the bacterial activity can be reduced to less than one-half of that observed at summer temperatures, and correspondingly lengthening the time for oxidation. This would mean that more than double the bacterial surface might be required to tide over such cold periods.

No purification takes place, of course, when sewage freezes, but fortunately we do not find conditions in the temperate zone where sewage cannot be kept from freezing. So long as it can flow, its temperature is sufficiently high to carry it upon the beds, and after an ice cover may have formed, the sewage continues to flow beneath it.

In the north of Europe sewage farms have operated successfully, and even the sprinkling processes have not been seriously affected, although no exact measures seem, as yet, to have been established. Nevertheless, there is a zone in our country where it becomes a question, yet to be decided by estimates of cost, whether housing or covering a filter bed will not sufficiently increase its minimum work to more than pay for the protection.

Undoubtedly, in the colder latitudes more time must be allowed on the average than in warmer latitudes, which means an increase of the necessary bacterial surface of a filter. This may be obtained by giving the bed a greater depth, or by decreasing the diameter of grain and correspondingly the size of the pores, so as to conserve the temperature of the sewage, which reduction in the size of grain may, however, require a more thorough preliminary treatment.

AN INTERESTING BRIDGE BUILDING INCIDENT is reported from a country district in the upper Mississippi Valley. A new steel road bridge of about 75 ft. span was needed, and the county authorities let the contract, under the County Engineer's plans and specifications. When the contractor brought the steel work to the site he found that it was too short to go in place on the bridge seats. The Board of Supervisors sent a special committee to look at the bridge. A local paper reports the outcome thus:

> The finished span was found lying near the piers, ready for use, but inadequate to the purpose for which it was intended. * * * The commissioners made complaint that the bridge builders had not met the specifications.
>
> * * * The contract contained a clause that any dispute relative to the construction of the bridge and its acceptance should be left for final decision to the engineer. It was under this clause that the matter was settled, although it was first feared that the township might become engaged in a law suit, the question at issue being close.
>
> The bridge builders finally decided to consent to lengthen the middle panel of the span in order to meet the requirements, the reconstruction to be done at their expense.
>
> All concerned expressed pleasure and approval of the prompt acceptance by the contractors of the conditions.

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All franchises for public-service corporations are required by statutory provision to be advertised for sale in California. The usual procedure, as we understand it, is to call for sealed bids and to name an upset price in the call. The new charter for Berkeley, Cal. (see Eng. News, March 25, 1909), contains many provisions which are designed to safeguard the public in matters of franchise grants. Besides calling for bids on the basis of percentage of gross receipts, the charter provides that after the bids are opened and made public a further chance shall be given for competition. The bidding in such cases must advance by at least ¼ of 1% over the highest bid already offered, and further advances must continue at the same rate. This plan seems to have much to commend it, particularly since the bidding need not be confined to those who have already submitted bids.

A provision of the charter which we do not think is so commendable is one requiring street railway companies to pave the streets between and for 2 ft. outside of their rails. This is really a relic of the days of horse cars, when a street railway company naturally desired to provide the paving which its motive power must use. The best authorities are now agreed that this franchise requirement is unwise: First, because it tends to create confusion as to the value of a franchise; and second, and perhaps of more importance, because all paving work should be constructed and maintained by the city.

As to putting up franchises at auction, or any other means of securing a municipal revenue from public-service corporations, the question arises whether it is not better, where practicable, to give the patrons of public-service corporations the benefit of the best and lowest-priced service possible, instead of trying to turn money into the municipal treasury. This is not so easy to arrange in the case of street railways as with other public-service corporations, in view of the stereotyped 5-cent fare of this country. Nevertheless, we think the subject is one deserving careful attention on the part of municipalities and public-service corporations alike. It is already being given consideration by many students of the subject.

A great advantage of the compensation-in-accordance-with-gross-revenue scheme is that it is automatic in its assuring to the public some of the advantages of increased patronage of the public-service corporations. Street railway fares and charges for lighting, water and the like cannot be easily altered except at considerable intervals. Moreover, the danger is that unless these intervals are rigidly fixed in the franchises, they will be altogether too long. Still further, it is to be noted that, except where efficient state public-service commissions exist, the chances are that provisions for adjustment of rates will not be exercised with intelligence on the part of the community. The whole subject is one demanding far more attention than it has yet received.

On April 28 the President and the Vice-President of the United States, the Ambassador from France to this government and a distinguished gathering of citizens, convened in the rotunda of the Capitol at Washington to do rather tardy honor to the remains of one of the early engineers of the republic—Major L'Enfant, to whom is due the plan on which the city of Washington is laid out. In 1825 L'Enfant died near the city which he had planned, a disappointed and almost unknown man. During the past 84 years his body has laid in an all but unmarked grave. At the last session of Congress, however, an appropriation was made for the erection of a suitable monument to his memory in the National Cemetery at Arlington overlooking the capital city. The ceremonies of last week, at which addresses were made by prominent officials of this country and France, were a part of the rites incident to the transfer of the body to the site of the monument in Arlington.

Pierre Charles L'Enfant was born in France in 1754, and was educated in her military schools. In 1777, when a lieutenant of engineers in the French army, following the lead of some of his more distinguished colleagues, he offered his services to the American colonists. In that army he was a brave and efficient officer. For three years he was in active service in the southern campaign until at the battle of Savannah he was severely wounded and then captured by the British. After his exchange for a Hessian officer, he returned to Washington's command, and in the following campaigns displayed military engineering skill of a high order. After the termination of the war, L'Enfant returned to France and there engaged in the practice of his profession until 1791, when, at the express invitation of President Washington, he returned to this country to superintend the laying-out of the new capital city, then recently authorized by the federal Congress.

In the planning of the capital city it is probable that three men shared the responsibility and should share the credit: Washington, who in his three-fold capacity as President, engineer and resident of the Potomac country, undoubtedly was the court of last resort by whom all plans had finally to be approved; Ellicott, the American engineer, who was really the first city engineer of Washington, and L'Enfant, fresh from the cities of Europe and the municipal and engineering reforms of the Directory. To L'Enfant is undoubtedly due the credit for originating the wonderful plan of the city. He had the marvelous foresight to provide for a city of 200,000 at a time when the largest town in the country had but 40,000 people. The city which he laid out on hills of virgin forest and fruitful farms corresponds so closely to the latest map of Washington that a detail study is needed to tell where changes have been made.

For a number of years L'Enfant worked at his ambitious scheme and founded the city as it now stands, but a certain intractability of temperament, mixed no doubt with political jealousies on the part of his enemies, brought him into disfavor with the American Government and he was dismissed from the service with what, to his mind, was entirely inadequate recompense. The remaining years of his life were spent in retirement and in almost constant quarrel with the authorities. He was buried in 1825 on a farm in Maryland, whence his body was removed last month.

Although the recent ceremonies recall the proverbial ingratitude of republics, they more vividly illustrate not only the desirability but also the practicability of city-planning. Major L'Enfant was a genius in this work; to that fact the present cities of Washington and Detroit, which he also planned, offer concrete proof. Conceived in an age when modern municipal necessities could hardly have been dreamed of, these two cities to-day are models of municipal design. The wide streets of varying width, the numerous parks, the broad avenues radiating from a center, the commanding public building sites, the convenient street naming, are all now included in the elements of the city-planner's art, but they were all a part of the theory which this French engineer officer applied to his practice, and which has survived through a century to make models of the cities where it was used. The success of L'Enfant, though it took nearly a hundred years to be demonstrated, should encourage those cities where city planning or replanning is in prospect.

Official Investigation of Railway Accidents.

The subject of railway accidents and their investigation is brought to public attention anew by an interesting paper recently read before the Western Railway Club by Mr. W. L. Park, General Superintendent of the Union Pacific Ry. The paper is abstracted on another page of this issue.

The Union Pacific has recently adopted a radically new policy in connection with serious accidents occurring on its lines. This policy is, in brief, to make public the facts in connection with the accident, as determined by an official investigation. This investigation is made by a board made up chiefly of officials of the railway, but with one or more members selected from outside sources. As a rule, some citizen of prominence is chosen. In one case a couple of retired army officers served on a board of inquiry; at another time a former superintendent of the Chicago & Northwestern Ry. was a member of the board. These outsiders are given a place in order to assure the public that the investigation is impartial.

This new practice by the Union Pacific is a radical departure from the time-honored custom which has prevailed on practically all railways, of covering up everything in connection with accidents and concealing it from the public. The reason which has been assigned for the secretive policy relating to accidents is that any information given out by the company's officers is likely to be used against the company in damage suits. It was shown by Mr. Park's paper and by the discussion upon it, however, that progressive railway officers realize that the old policy so long followed has been a mistake. It is recognized that the public has a certain right to know the real facts concerning any grave disaster involving serious loss of life. Of course, this public right is recognized in the law, in the provision made for coroners' investigations; but it need hardly be said that such investigations are almost always a mere farce, so far as the determination of the real facts is concerned.

The Union Pacific is to be highly commended for its new departure. On the other hand, we cannot so fully agree with one of the main arguments which Mr. Park brought forward as a reason for the adoption of this new policy. He referred to the recommendations of the Interstate Commerce Commission, that official investigation of accidents be made by government authorities, and strongly deprecated what he termed the "meddlesome public interference in operating matters with which we are now threatened." According to Mr. Park, one reason for the establishment of this new policy of publicity by the Union Pacific is that the public demand for official investigations of accidents by government officers may be counteracted.

It seems to us that this is a most unfortunate position. The accident investigation recommended by the Interstate Commerce Commission

in repeated annual reports would actually be to the advantage of the railway companies as well as of interest to the public. We cannot but feel that Mr. Park's opposition, and the opposition of other railway officers who hold similar views, is based on misapprehension and misunderstanding. What the Interstate Commerce Commission has recommended is practically to establish an expert investigation in this country, similar to what has long been established in Great Britain. We find this recommendation heartily approved in a recent bulletin issued by Mr. Slason Thompson, of the Bureau of Railway News and Statistics of Chicago. Mr. Thompson, at the conclusion of his pamphlet, makes the following definite recommendations:

That Congress provide for an official investigation of all railway accidents in the United States on lines patterned after the methods so successfully adopted in the United Kingdom. It should be a Bureau of the Department of Commerce and Labor, composed of:

One Chief Inspector.

Ten District Inspectors, one for each of the groups into which the country is divided, in railway statistics, appointed from U. S. A. engineer service with rank of Major.

Three Deputy Inspectors for each group.

Three Assistant Inspectors for each group.

Three Sub-Inspectors for each group.

Several groups might require four inspectors of each class and as many could get along with only two

The various kinds of accidents should be apportioned among these inspectors according to their nature, as they are in Great Britain, and the inquiries should follow without delay as they do there.

We need hardly say that Mr. Thompson will not be accused of being opposed to railway interests, or of promoting legislation which could in any way be construed as "meddlesome interference" with railway operations.

The fact is that present-day investigations of accidents, whether conducted in secret as is usually the rule, or conducted with publicity as Mr. Park proposes, fall far short of what is needed for the benefit of good practice in railway operation. Mr. Park himself admits that a good many of the accident investigations now conducted amount to very little. The regular operating officers are busy with routine duties which must be attended to and cannot spare the necessary time to do such work well. Further than this, the men who make the investigation are often those who are, directly or indirectly, more or less responsible for the causes of the accident. Most important of all, however, is the fact that accident investigation is a special line of work. A man of long experience in this work, such as Col. Yorke, one of the expert investigators of the British Board of Trade, will find the causes of an obscure accident where the average operating official would often be completely puzzled and give it up as a mystery.

Probably the opposition of Mr. Park and other railway officers to the proposed bureau of accident investigation is due to the idea that the work of investigation would be a mere routine clerical matter, turned over to employees unfamiliar with railway practice. Certainly such investigations would be a farce, and an injury rather than a benefit. But we know of no reason to expect that the law would be executed in such a manner. What would doubtless be done would be to select from the ranks of railway officers themselves a number of men, with thorough knowledge of the different departments of railway work, such as signaling, engineering and methods in the traffic department. These men would do well and efficiently what is now done crudely, or not done at all.

An additional argument for such a system of accident investigation is its influence upon discipline. Mr. Park in his paper frankly recognizes the difficulties which are encountered at the present day, in training and disciplining the operating force. It would be a distinct advantage if a division superintendent, for example, could be relieved from the duty of fixing upon a certain signalman the responsibility for a mistake, and could simply use the official record by an impartial investigator as the basis of his action. The liability to such investigations would be a spur to vigilance on the part of the whole operating force, from the highest official to the lowest employee.

The present law requiring reports of accidents to the Interstate Commerce Commission is of trifling benefit. When the law was enacted in 1901, it was urgently desired that the law should take such form as would permit real, expert investigations to be established. It was through the influence of prominent railway officials, unless we are much mistaken, that the law was emasculated, and the opportunity for the establishment of a proper system was allowed to pass by. We believe that our railway officers have learned wisdom in the past ten years, and it ought to be possible at the present time to secure the necessary legislation in Congress to bring about what has been so long urged by the Interstate Commerce Commission.

Public Expenditure for Inland Waterway Improvements.

We present to our readers in this issue several papers describing work for the improvement of navigation on inland waterways. In view of the present public agitation for waterway improvement, these papers are especially timely and important and are worthy of careful study.

The two papers describing work to benefit navigation on the Tennessee and on the Cumberland rivers are written from two very different standpoints; but the facts recited in both papers make it clear that the policy of river improvement pursued in the past—if it could be called a policy—has been wasteful and absurd. Briefly summarized, improvements to benefit navigation on these rivers were planned soon after the war, when railways and other means of land transport in the South were almost wholly lacking, and when the river steamboat was still a very important factor in the movement of internal traffic.

Year after year for nearly two-score years the work has dragged along and is not even now completed. The result is that notwithstanding some spasmodic attempts to modernize the plans, the improvement work appears to be obsolete before it is completed. Many millions of dollars of public money have been spent, but the traffic to justify the expenditure is not in sight.

That public work carried on in this fashion is a lamentable waste of public funds has been many times pointed out in these columns and elsewhere; but error has often been made in placing the blame for this waste. It is the system that is radically at fault, rather than the men who have administered the system. The individual officer of the Corps of Engineers is powerless to effect a change and the individual Congressman is almost as helpless. The public has not in the past and does not to-day look to the Corps of Engineers to originate or recommend plans for waterway improvement. It does not even welcome the advice of these engineers in reporting upon offered projects. Each city and each district wants to boom the waterway schemes in its own locality; and many an engineer officer has made himself unpopular because he could not as an engineer approve some of the schemes brought forward in the district where he happened at the time to reside.

Instead of blaming the Corps of Engineers for failing to develop an efficient system of internal waterways, we feel that many members of the Corps deserve great public credit for the efforts they have made to make the best of a bad system, and for the influence they have exerted to prevent expenditure of money on works which were manifestly unwarranted.

It is sometimes claimed, we are well aware, that such matters as this of waterway improvement are for business men to decide and that the engineer should merely take a back seat until he is called upon to execute whatever work may be decided upon. We wish to register emphatic dissent from that proposition. The problem of economic transportation is an engineering problem. For its intelligent solution a broad knowledge of engineering is essential. Of course one could not pick out engineers at random and expect from them reliable solutions of such a problem, any more than you could choose engineers at random to build a great railway or exploit a difficult mine or plan a vast sewerage system.

The root of the difficulty with our internal waterway development of the past is that it has been a matter of haphazard growth. The engineer has seldom had a chance to plan on broad lines and when he has made plans there has been no assurance that the plans would be carried out before the whole work became obsolete.

At the present time a huge campaign for waterway improvements is in progress. Paid lecturers are going about the country circulating false and most foolish statements regarding the public benefits to result from expenditure on waterways. The newspapers teem with similar statements. There is grave danger that the nation will be plunged into an abyss of debt for waterway construction. Many interests conspire to forward such measures. One of the largest and most influential banks in New York recently issued a circular in which it urged that the Nation should issue at least a thousand million dollars in bonds, because it was wealthy and prosperous enough to afford to pay the interest.

From such financial and economic heresies—heresies put forth with the motive of private gain—may the Nation be delivered!

One of the dangers which constantly beset the Nation and the states is the expenditure of public money on unwise projects. And any project is unwise unless it will return a resultant benefit proportionate to the expenditure. The question "will it pay," is the one that ought to be settled and settled with the aid of experts, before the taxpayers' money is spent. And if the proof is not forthcoming that a project will pay, directly or indirectly, it had better be abandoned. There are ways enough in which public money can be profitably spent and for which expenditure is urgently needed, without undertaking any quixotic schemes.

We need hardly say that Engineering News is not opposed to waterway improvements where they are planned and executed on proper lines and are justified by commercial requirements. We *are* opposed to frittering away the public money on alleged waterways which serve no purpose other than to secure the expenditure of public money in a certain Congressman's district, or to benefit some private owner of water power or to make business for a contracting firm.

We have alluded above to the work for navigation improvement on the Cumberland and Tennessee rivers. If the country is to have an intelligent policy of waterway improvement then investigation ought to be made to determine whether under present-day conditions *any* improvements of these rivers can be made to pay. Manifestly it is folly to spend vast sums of money building locks and dams on these rivers unless commerce is going to make use of them. And traffic will not seek the rivers unless they offer on the whole a cheaper route than the railways.

We are aware that the stock argument of the waterway enthusiast is that the waterway is a profitable ally of the railway because it carries the coarse bulk freights and leaves the railway the high-class freights which pay a high profit. The unfortunate thing about this stock argument is that it is not true. The railways of this country make their greatest profits from hauling those very same bulk freights. Of course, if a waterway can move freight at less cost than the railway, as can undoubtedly be done on the Great Lakes or on the ocean, the railway has to be content with such traffic as it can get, and has to meet the competition as best it may.

Even under such circumstances the railway usually secures considerable traffic, for the great bulk of inland freight business originates or ends at points remote from waterways. Unless the distances to be moved are great, it seldom pays to transfer a shipment from a car to a boat and again to a car to complete the journey.

But it is said that the railways of the country are unable to keep pace with the growth of

traffic and that waterways are a necessity to prevent congestion on the railways. Before we accept this argument at face value let us inquire about this alleged congestion of the railways of the country. It is not apparent as yet in this year of 1909, nor was it in 1908. We should not make the mistake of taking the abnormal conditions at the climax of the boom of 1906-7 as typical of the railway situation.

Again, even when the boom of two years ago was at its height, it was only a small percentage of American railways which were unable to handle all the freight that was offered them. The congestion was really a scarcity of cars and locomotives and in some cases a clogging of yards and terminals, which can be and in many cases has been remedied by better administration and better methods.

One of the stock arguments of the waterway advocates is the work which has been done in Europe in the development of internal waterways. It is argued that the United States ought to embark on similar projects for waterway improvement.

Before we accept this argument, however, careful and unprejudiced inquiry ought to be made as to the difference in conditions between the United States and foreign countries. In this connection Col. Townsend's paper in this issue on the improvement of the Upper Mississippi River is of very great interest. The Mississippi River, from St. Paul to the sea, is and has been for many years a waterway superior in capacity to any river of Europe, yet traffic upon it has dwindled year by year. In the discussion upon Col. Townsend's paper, the fact of falling off in traffic was freely admitted, and it was stated that the river commerce now is confined principally to short distance traffic. The important traffic from manufacturing centers and the passenger movement has dwindled to a large extent. In discussing the reasons why traffic does not seek the waterways here as in Europe, Capt. Wm. V. Judson offered the following explanation:

> It appears that commerce has been declining on the Mississippi River, regardless of the fact that the river is a foot and a half to two feet deeper than it was formerly; that is to say, nearly twice as deep as it was in its original state.

We are often confronted by such facts in our American river improvements. I have an explanation of this situation in mind, which I believe is more or less correct. We all know that most of the commercial cities abroad were built before the days of railroads. Naturally these cities were located on lines of water communication, and conformed in many ways to the necessities of water transportation. Large amounts of money were spent in improving the streams before railroad building came along.

Abroad the continent is cut up politically into small portions, and railway trunk lines are, as a rule, short. Economies in railroad transportation have not been introduced abroad to the extent that they have been in this country. On the other hand many of our American cities have been built or have developed since railroad construction began, and have conformed in their development to the necessities and conveniences of rail transportation. It is to be expected therefore that we should find much more traffic on shallow interior waterways in Europe than in America.

With regard to the great public discussion we are having now with reference to inland waterways, I must confess it seems to me that many of the great projects advocated are, to say the least, of an experimental character, without sufficient promise of satisfactory commercial results. I am not prejudiced against waterways, and I know there is, from an engineering standpoint, most interesting work to be done in the improvement of rivers.

Great systems of internal waterways were projected some fifty years ago, but in many cases, after large expenditures, it was shown that these waterways would not be profitable and the schemes were abandoned to a great extent, which I think was wise. Yet there seems to be danger that this same lesson will have to be learned over again.

It seems to us that Capt. Judson's statement deserves the serious consideration of those who would give really fair study to the question of waterway improvement. Examine conditions in American factories and warehouses and you will find them located almost invariably on a railway siding. Often railway tracks run all through a manufacturing plant. In Europe, on the other hand, waterway terminals are everywhere to be found. The American manufacturer will not send goods by water when he can load or unload directly on a railway car in his own factory. The cost of trucking to or from a steamboat wharf would often neutralize all the saving that water transportation could effect

Much more might be said, but the above should be sufficient to show that we may not safely take European precedents in waterway construction as a guide in our own policies without considering also the difference in conditions between the two countries.

LETTERS TO THE EDITOR.

Graphical Analysis of Parallel-Chord Trusses Under Uniform Load.

Sir: An article by J. H. Griffith on a "Simplified Method for Graphical Calculation of Bridge Trusses" in your issue of Feb. 25 leads the writer to present a graphic scheme which he has used for some time. Like Mr. Griffith, he claims nothing particularly new, though so far as he is aware no similar method occurs in any text book.

Whether a method is cumbersome or not depends upon the skill of the operator and his familiarity with that particular method. For instance, Mr. Griffith's method of drawing the parabola chords, or rather, finding points on the parabola, seems cumbersome to the writer, who would preferably draw the diagonal $A_0 B_8$ (referring to Mr. Griffith's diagram) and with the T-square take points on the left vertical $A_0 B_0$ horizontally opposite the intersection of the diagonal with the verticals. The lines joining the points on the left vertical (need not be drawn) with B_8 give parabola points on corresponding panel verticals. The spacing of the verticals may or may not be equal.

These reaction loci are composed of chords of the true parabola for uniform loading, but if drawn as suggested in Art. 20 of Greene's "Trusses and Arches," the lines are tangents of the parabola, and as there shown the intercepts on this diagram give exact shears for uniform load concentrated at the panel points, without the subtraction of $\frac{pd^2}{8l}$, as is required in methods where the chords are used. Also, since Mr. Griffith uses points at the center of the panels, these points, being on the parabola, represent the left reaction when the uniform load extends midway into the panel. This position, of course, does not give maximum shear, and since the true position and the consequent maximum shear are just as readily found as the approximate, the writer suggests the method shown in the lower part of the accompanying drawing, which consists simply in drawing the shear instead of the reaction locus.

For a maximum shear, therefore web-stress, the uniform load extends into the panel to the neutral point $X = \frac{np}{m-1}$, from which equation it is readily seen that if the panel-length is divided into one less parts than the number of panels, the points of subdivision define the limits of the uniform load for maximum stresses in the web members. Drop verticals through these points, and then find points on the parabola as suggested, the left ordinate being made equal to the maximum shear in the left panel, $= \frac{wl}{2} - \frac{wp}{2}$.

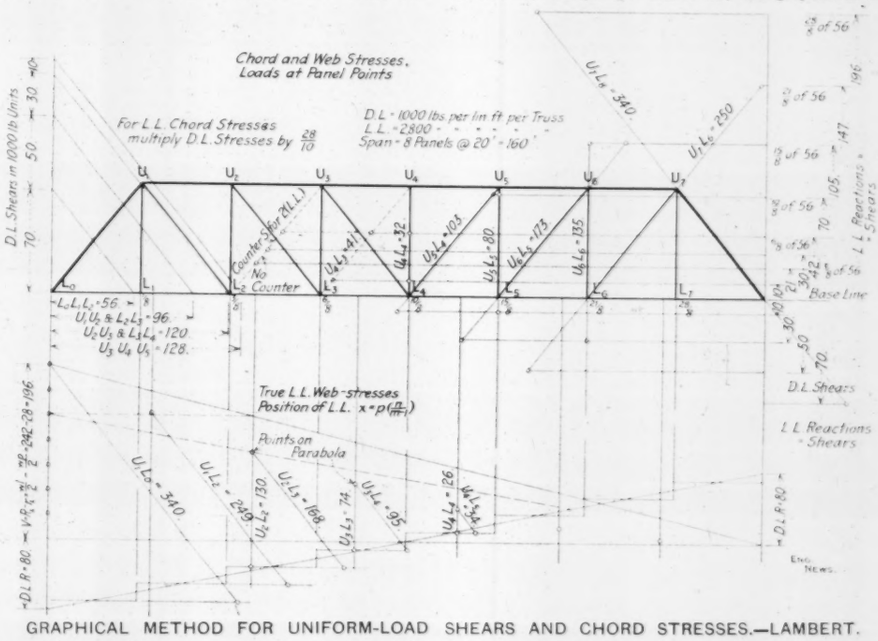
In ordinary practice, the stresses in a parallel-chord bridge are found so readily algebraically that it would be a waste of time to solve them graphically; but in class-room work it is highly desirable to work from the simple to the more complex, and also to explain algebraic methods, although at the time the instructor fully appreciates the fact that these methods may never be very extensively used in practice. For example, the writer, in addition to the ordinary stress diagrams, influence lines, and equilibrium polygons commonly employed makes use of the system shown in the upper part of the drawing in dealing with parallel-chord bridges. This is readily seen to be only a graphic method of resolving shears, and from them finding all maximum and minimum stresses in both webs and chords.

Respectfully,

B. J. Lambert,
Assoc. M. Am. Soc. C. E.

Iowa City, Iowa, March 7, 1909.

Sir: Referring to Mr. J. H. Griffith's article in Eng. News of Feb. 25, page 224, entitled "A Simplified Method for the Graphical Calculation of Bridge Trusses," the method would seem to be a simple one for the case given, and likely has merits which I have failed to notice; but the question arises, why use graphics at all in that case where the analytical method may be used with seemingly less labor, as follows:


Chord and Web Stresses, Loads at Panel Points
For L.L. Chord Stresses multiply D.L. Stresses by 28/10
D.L. = 1000 lbs. per lin. ft. per Truss
L.L. = 2800
Span = 8 Panels @ 20' = 160'
Counter Shear (ALL L.L.)
No L2 Counter
Base Line
True L.L. Web-stresses
Position of L.L. x = p(n/(n-1))
Points on Parabola
D.L. Shears
L.L. Reactions = Shears
D.L. Shears in 1000 lb. Units
L.L. Reactions = Shears
Eng. News

GRAPHICAL METHOD FOR UNIFORM-LOAD SHEARS AND CHORD STRESSES.—LAMBERT.

For chord stresses: Let the maximum chord stress $\frac{wl^2}{8h} = a$. Then using Mr. Griffith's figure and notation, by the laws of the parabola the ordinates representing the chord stresses whose centers are L_3, L_2 and L_1 would be $a - \frac{a}{4^2}$, $a - \frac{4a}{4^2}$ and $a - \frac{9a}{4^2}$, respectively.

If there were 5 panels in the half span, the stress ordinates would be $a - \frac{a}{5^2}$, $a - \frac{4a}{5^2}$, etc. To obtain the bending moment only, we would use the formula of the parabola transposed for this case, which is

$$M_1 = M - \frac{w}{2} x^2$$

where M = maximum bending moment $= \frac{wl^2}{8}$

M_1 = moment at any point distant x from the center of the span.

For live-load web stresses: The formula of the parabola becomes

$$S = \frac{p}{2l} x^2$$

where p = the load per foot and S = the live-load shear at the end of the load at a point x distant from the loaded end.

The solution of the parabola becomes very simple when

we know the vertex and the ordinates of one point and this seems to be a case where that formula can be used to advantage.

Yours truly,

E. E. Greenwood.

Skowhegan, Me., March 16, 1909.

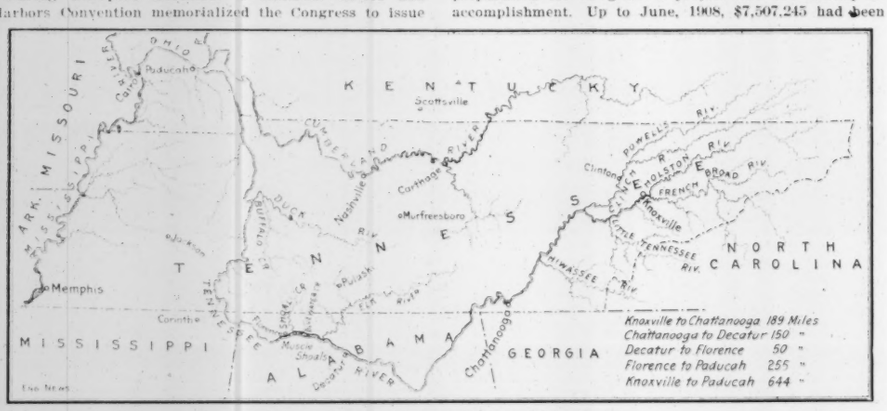
The Improvement of Our Waterways; with Special Reference to the Tennessee River.

Sir: The unexpected and phenomenal development of our natural resources during the past decade resulted in such congestion of railway traffic as partly to paralyze industry, and the inability of those in authority adequately to prepare for and meet the emergency has directed the public attention as never before toward our inland waterways as a source of relief.

The situation was clearly voiced by the late Senator Morgan of Alabama, Chairman of a select Congressional Committee in the following words:

The enormous tax upon industry and commerce that is assessed by the railroads to pay interest and profits on these investments, and the just control of these assessments by competition, is directing the hopes of the people toward water transportation as the only certain and permanent relief that is in the reach of the powers of Government or of the people.

During the past December a National Rivers and Harbors Convention memorialized the Congress to issue bonds of the Government in the stupendous sum of five hundred millions of dollars for the improvement of the Nation's waterways. This popular demand had several years before been anticipated by Senator Morgan's Senatorial Committee, which declared that "we are at the beginning of the improvement of our great internal system of navigation," and realizing the magnitude of the undertaking, it urged that the greatest care is needed to establish its proper adjustment, "so that its usefulness shall keep pace with the growth of the country, and its results shall be one of the chief glories of the Republic."



MAP OF THE TENNESSEE RIVER.

That the President radically disagreed with the Rivers and Harbors Congress in the recommendation that future waterway improvement be entrusted to the Engineer Corps of the Army was a matter of surprise to most well-informed persons, the general belief being that Mr. Roosevelt indulged a decided bias toward the military establishment. Nevertheless, in the message quoted there appears a most scathing and severe arraignment of the past practice of detailing the Corps of Engineers to civilian duties, the contention being that not only has the result proven a failure to give inland navigation, but was injurious to the army efficiency as well.

As to the future work the President held that the military engineers are

necessarily unsuited by their trainings and traditions to take the broader view and to gather and transmit to the Congress the commercial and industrial information and forecasts upon which waterway improvement must always so largely rest. Furthermore, they have failed to grasp the great underlying fact that each stream is a unit from its source to its mouth, and that all of its uses are interdependent.

In concluding, the President left no room to doubt his fixed belief as to the unwisdom of the assignment of the army engineers to such duties, and stated in the following words:

So with the improvement of our rivers, it is no longer wise or safe to leave this great work in the hands of men who fail to grasp the essential relations between navigation and general development and to assimilate and use the central facts about our streams.

The President justified this indictment by reference to the

"improvement" of the Ohio River, which began in 1824, was continued under a single plan for half a century. In 1875 a new plan was adopted and followed for a quarter of a century. In 1902 still a different project was adopted, and has been pursued at a rate which only promises a navigable river in from 20 to 100 years.

The Ohio is only one of many where the same story of uncertainty, prodigal waste and lack of results might be told.

THE IMPROVEMENT OF THE TENNESSEE RIVER.—The history of the improvement (?) of the Tennessee is one which almost challenges belief in the lack of preparation for so great a project and the futility of accomplishment. Up to June, 1908, $7,507,245 had been expended upon this stream for construction work alone, while $1,075,066 was used for operating and the care of the Muscle Shoals Canal, one of the features of this project. In a report to the Chief of Engineers, in 1901, Col. Henry M. Robert, after an inspection of the river from 50 miles below Knoxville to the mouth, during which this officer found it necessary to change boats frequently "because of the disconnected improved parts," significantly says: "The work done heretofore below Chattanooga is of little value at present and will remain so until the river as a whole is improved," and this after some seven millions of dollars had been expended upon the section alluded to in the report for "improvement" work commenced seventy years before!

The Tennessee River is formed by the junction of the French Broad and the Holston rivers just below the city of Knoxville, Tenn., and empties into the Ohio River near Paducah, Ky., a total length of some 653 miles. This with its tributaries constitute a system of waterways of over 2,400 miles, draining a populous area of about 44,000 square miles. The low water discharge at Knoxville is estimated at 26,250 gals. per sec.; that at Chattanooga, some 60,000 gals. per sec.; while at its mouth the low water gaging gives 75,000 gals. per sec. of flow. From Knoxville to a point some 30 miles below Chattanooga, the Tennessee flows nearly south, between the mountains of east Tennessee; there it breaks through the mountain chain at Hale's Bar, and flows west for a distance of 230 miles, through Alabama to Riverton, where it enters a broad valley of West Tennessee; thence, northerly and parallel to the Mississippi for a distance of 226 miles, to its junction with the Ohio.

For convenience, the Tennessee has been subdivided into the sections above Chattanooga; a section from Chattanooga to Riverton and that below Riverton, Ala., to Paducah, Ky. Above Chattanooga, the depth of the water varies from 10 to 30 ins. at the low stage, with an average slope of 0.956 ft. per mile, and current rated at 6 miles an hour in some places. This section of the river is obstructed by rock reefs, boulders, gravel bars and snags. In the middle section the average slope is 1.5 ft. per mile from Chattanooga to Scott Point (17.5 miles), thence 0.4 ft. per mile to head of Muscle Shoals Canal, then 2.73 ft. per mile to Riverton (62.5 miles). Below Riverton to Paducah (226 miles) the average slope of the river is 0.34 ft. per mile, and this stretch is navigable at nearly all seasons of the year to the usual river craft.

The improvement of the upper river contemplated a 3-ft. stage at all seasons of the year; for the middle section 5 ft. of water was proposed; while no definite plan has been announced for the lower division, although 6 ft. is provided for at Colbert Shoals.

According to a late report by Maj. Wm. W. Harts, Corps of Engineers, above Chattanooga the maximum draft that can be carried at mean low water over the shoaliest places is about 18 ins., the present project being to maintain the navigable waterway by the removal of minor channel obstructions and the repair of existing works of regulation. Between Chattanooga and Brown's Ferry, just below Decatur, the river is obstructed by bars, boulders, reefs and rocky projections, the worst division being between Chattanooga and Hale's Bar (33 miles.) At this point, under authority of Congress, a lock and dam is being constructed by private parties as an industrial development, which will submerge all existing works and provide at least 6 ft. of water at Chattanooga, at the low stage. This project is intended to develop some 60,000 HP., and is now well under way.

Under a former project, the river below Decatur, and known as the Muscle Shoals section, was improved at Little Muscle Shoals by some channel work, and by the construction of a lateral canal in two divisions, one on the left bank about 3.5 miles long with two locks, around the Elk River Shoals; and the other on the right bank about 14.5 miles long, with 9 locks, around the Big Muscle Shoals.

This Government Canal is the most important feature of the attempted improvement of the Tennessee River, and was undertaken by the State of Alabama under plan of United States officers in 1831. National aid was given through the dedication of the proceeds from the sale of 400,000 acres of the public lands. The original project contemplated the canalization of the river at this point for a distance of 14.5 miles, 60 ft. wide, and to overcome a fall in the river of some 85 ft. within the distance through the use of 17 locks, each 120 ft. long between sills and 32 ft. wide.

The original work cost $700,000, but because of the limitation to navigation from the shoals immediately above and below, proved of so little value to commerce, that the tolls for traffic failed to provide a fund sufficient for its maintenance, so that it gradually fell into disuse; the wooden locks rotted away; the main canal filled with silt, and a flourishing growth of willows and cotton wood destroyed all possibility of navigation.

During the year 1875 the National Government undertook its rehabilitation under a new plan of construction, providing for a canal practically over the same ground, but to be operated with 9 locks, 60 ft. wide and 300 ft. long, with an established depth of 5 ft. of water at the locks and 6 ft. at other points, the main trunk to be from 70 to 150 ft. wide. At the same time a canal of 1½ miles with 2 locks of like dimensions was projected to pass the obstructions offered by the Elk River shoals, separated from the Muscle Shoal works by some 8 miles of open river.

After 15 years these later works were completed at a cost of upward of $3,000,000, but as with the original project, effective service is prevented by the unimproved sections above and below. In 1890 the plan and estimate of a board of Army Engineers provided for a further expenditure of $4,000,000 for the improvement of Little Muscle Shoals and Colbert Shoals, which work is at this time in progress.

One of the principal features in the structural details of these works as far as completed is a steel viaduct 60 ft. wide and 900 ft. long, spanning Shoal Creek, a tributary entering the river at that point. In the latter part of March, 1902, a portion of this structure was destroyed by floods, preventing navigation for three months, and its repair cost some $17,000. This viaduct is reported to be "a constant cause of anxiety" and "the steel plates that form the trunk of the viaduct are already weakened by oxidation in many places. In these places the rust has eaten away one-half the thickness of the plate within the period of about 15 years since the viaduct was constructed. As no way is known to prevent such decay, it will result in the destruction of the plate inside of 20 years, when the cost of repair would equal the original cost of construction."

Under the plans adopted by Congress, the depth of water over the several miter sills of these locks was fixed, as has been stated, at 5 ft., but as a matter of fact, through the bungling and error of the engineers in charge, the minimum depth of the lock at the lower end of the upper canal is only 2.2 ft., while the two locks at the extremities of the lower canal show a depth of 2.8 and 3.6 ft., respectively, of course limiting navigation to the shallowest depth. But omitting defects of details, and considering this canal project broadly, the list of boats navigating this canal, exclusive of Government craft, averages from 12 to 14, of which only 2 are over 100 tons burden, and only one is engaged in through trade, during a limited portion of the year.

The value of this last improvement, costing upwards of $3,000,000 for original construction and more than $1,000,000 for operation and repair may be gathered from the uncontroverted statement of Mr. Frank S. Washburn, President and Consulting Engineer of Muscle Shoals Hydro-Electric Power Company, a corporation desiring to utilize the immense power of these shoals, in his communication to the Board of Engineers ap-

pointed under the Provision of the River and Harbor Act of March 2, 1907, to consider this project. In part Mr. Washburn's argument was as follows:

Not only is the Muscle Shoals Canal obsolete, but it stands as a positive block to the adoption of such devices and methods in transportation as are absolutely necessary in this latter day to meet successfully the requirements as to celerity and low cost of transportation. The immediate physical limitations upon its capacity and practicability are the excessive length of its shallow and narrow tortuous channel and the excessive number of locks; contributing to these difficulties during the low water stage of the river is the great leakage and the small flow of water into the head of the canal. . . . The lack of depth is a most apparent and unquestioned limitation upon the usefulness of the canal in a broad sense. . . . The largest boats very often have to tie for hours on account of wind, for they cannot attain sufficient headway to give them steerage power. Usually a locomotive is used to assist in keeping the boats off the bank during high winds. . . . From this it is clear that even if the canal had sufficient depth, if such boats as are used on the Ohio River attempted to bring their tows through Muscle Shoals Canal, it would require something in the neighborhood of two weeks to pass the canal, and that if this were attempted at periods of low water, it would be impossible for the canal to accommodate any other commerce for two weeks than the single tow boat and its fleet of barges.

Referring again to the Senate report, the select Committee concludes that

the improvements that have been made have already reached the limit of usefulness and they are in fact, obstructions to a great volume of commercial values that remain dormant where it was created by Nature. . . . The duty first to be performed and the manifest necessity in respect of the navigation of the Tennessee River, is to *remove and submerge* all obstructions between Knoxville and Paducah.

Thus would disappear not only the Government Canal at Muscle Shoals but the new works now under construction and estimated to cost four millions of dollars.

On the upper reach of the river, from Knoxville to Chattanooga, in 1871, the cost of its improvement for a 3-ft. stage of water as estimated by the U. S. Engineers was $225,000. This was revised by them in 1893 to $946,000 with a later estimate in 1907 of $1,709,152.85. In view of the radical and progressive increase perhaps the decimal might, with propriety, have been omitted! However, this may, after all, be immaterial since the latest from the officer in charge reports.

In the light of experience there seems to be some question whether the Tennessee River above Chattanooga can ever be satisfactorily improved by regulation so as to provide for a commerce of national importance. The history of the estimates for this work shows that the economy of the system would not be so great as was formerly hoped.

And this after the expenditures made for years and the recurrence of this stereotyped phrase first appearing in the annual report for 1891 of General Thomas L. Casey, Chief of Engineers, and reiterated in 1892-1893-1895-1896 and 1897 by succeeding officers as follows:

The radical improvement of the Tennessee River, so as to make navigation continuous for boats of moderate draft, is by no means an impossibility.

The select Committee of the Senate, before alluded to, in its report to the Congress, was either unaware of this pronunciamiento, or the Army Engineers refrained from contributing to its enlightenment their plan for making this dream come true, since the only tangible suggestion to the Senate Committee for the systematic improvement of this waterway and endorsed by it came from "an able and experienced man who has spent fifteen years in practical work on the Tennessee in the central and western divisions."

Since the gentleman's name is withheld it is a fair assumption that the plan proposed and recommended did not emanate from any officer of the Engineer Corps, especially since of the eleven army officers in charge of the lower river improvements during the past 18 years, the longest single term of assignment to this service was four years. In 1895 one of these officers, although also holding out the glittering generality of continuous navigation "being by no means an impossibility," etc., admits that

The improvements attempted at many of these places have proved abortive because the localities have been worked on independently. In so far as the work has been confined to removal of boulders and snags, it has been successful, but excavation resulting in change of conditions of flow is very dangerous to attempt in river improvement unless long reaches above and below have been mapped, profiled, measured for discharge and thoroughly studied beforehand. Without such preliminary study hoped-for improvements from excavation is more apt than not to result in developing obstructions at places which were navigable before.

Even to a layman, such preliminary surveys and studies as will systematize and co-ordinate the work appears a first necessity, and yet in the same report this officer calls attention to the fact that even as late as 1891 such data are lacking . . . "although many detached surveys exist, which are now being patched together. A continuous map and profile with discharge measurements taken at different stages of water, is sadly needed for the whole river below Chattanooga. A comprehensive and logical plan for the complete improvement of the river will only then be possible."

And this after 37 years of continuous improvement (?) and the expenditure of upward of eight millions of the public funds.

Who shall say that the President is not right "that the time for playing with our waterways has passed."

Very truly yours,

James Nisbet Hazlehurst, M. Am. Soc. C. E.

Candler Bldg., Atlanta, Ga., March 8, 1909.

Surface Retardation in Open Channels.

Sir: In the issue of April 15 of Engineering News, appears a summary of the conclusions reached by A. H. Gibson in a monograph, "On the Depression of the Filament of Maximum Velocity in a Stream Flowing Through an Open Channel."

Mr. Gibson's observations were evidently all made on narrow channels, where the disturbances due to roughness of the sides were felt in midstream. In very wide rivers and channels it is unlikely that this is more than a minor cause of the surface retardation. The filament of maximum velocity in wide channels is but little below the surface, in the middle portion of the stream. There is nothing unreasonable in assuming that, beyond the strip bordering the bank (to which the phenomenon Mr. Gibson has observed is limited), the surface velocity is retarded simply by the friction of the air on the water, and the greater resistance that the surface film offers in adjusting itself to differences in velocity throughout its course and width, compared with the more fluid interior portion.

The fact that the friction of the surface is neglected in empirical formulas for the flow in open channels is allowable only because it is small compared with the uncertainty of the coefficients of friction used to determine the resistance offered by the bottom and sides. The so-called "friction coefficients" used in formulas to determine velocity in open channels are much overworked as usually applied in practice, and often are made to cover losses of head due to varying cross-section, minor obstructions, and alinement changes, besides the surface disturbances. In artificial channels, such as flumes and lined canals, where the section and alinement can be maintained, the friction losses are determinate within working limits, separate from other losses of head; but the flow in channels which are free to adjust themselves to the conditions of changing flow, such as rivers and artificial channels in earth, does not admit of such exact division of the lost head.

Yours truly,

Winfield Holbrook.

Granite, Colo., April 19, 1909.

Is an Engineering Education a Foundation or a Finial?

Sir: The writer has been particularly interested in the recent letters regarding an engineer's salary and qualifications and trusts that his views on these two subjects may lend some encouragement to the struggling.

Let me say at the outset that an engineer is a practical application of the "survival of the fittest." An engineer's experience is the foundation upon which his future is erected and a college education may be classed as the finial that completes it.

But just as a house is habitable without the finial so it is uninhabitable without some foundation. The engineer of experience can successfully follow his profession without a college education whereas the college graduate cannot without the experience.

As a rule, with notable exceptions, however, the college man is supported in a mistaken idea of men and affairs by an indulgent parent and as a consequence feels that he is ill-treated when he fails to make a big splash upon the presentation of his diploma. Engineering work is done by men who can do things and not by men with imaginary qualifications. Is the self-educated engineer of experience to be looked down upon by members of his profession because he is not a college graduate? Or is a college graduate any better qualified to be an engineer because he has a diploma? In the first case the education of the engineer is being slowly built up of perfect knowledge and the solid matter only retained. In the second case the instruction is dumped into a receptive or non-receptive brain and must be discarded as time goes on and experience demonstrates.

Fifteen years of continuous application is the minimum time for any engineer to think of looking at his salary in preference to the work upon which he is engaged.

In spite of this, colleges are turning out men as engineers who only look at the immediate return in salary and who have not the natural abilities to fill an engineer's position. These men have absolutely no notion as to the practical side of engineering and are so full of theory as to make them incompetent on work of any responsible character, until they have cleared their minds of this burden. It is this unloading process that makes the engineer and the salary is small during the making.

There will be no over-production of good engineers since the man who is to be a good engineer is one who has the courage to keep everlastingly at it every day and all day year in and year out and stand upon his feet through all discouragements. In time he will be called upon to give to the world a monument to his everlasting credit or discredit in the form of some work of engineering and then will the life of the engineer be started along that mythical path of roses or ended in oblivion.

Benjamin L. Williams, Jr.

East Orange, N. J., April 24, 1909.

[If our correspondent were better informed as to the work of the engineering colleges, we think he would agree that an engineering education may be more truly likened to a foundation on which the superstructure of experience is to rest. The self-educated man deprived of the college training may nevertheless become a successful engineer, but he will have to put in the foundation of sound theory as he builds the superstructure of experience if he is to attain highest rank as an engineer. Those who do this deserve all the more credit, and only men of small mental stature would think of "looking down on them."—Ed.]

More Advice to Young Engineers.

Sir: The earnest inquiries of a "three year old" in your issue of March 4, have not been treated with the respect they deserve. The young man has not received kindly treatment at the hand of his older brothers in the engineering profession. There has been evident in all the letters a spirit of levity that the writers should be ashamed to exhibit. They are no doubt all successful now and willing to make light of their own struggles, now happily past, and forget how serious the same things were viewed by themselves not so many years ago.

My dear "three years old," I am almost a "twenty-five year old" and my period of hard times is still too fresh in my memory to permit me to pass you by without trying to give some comfort. I have paid a high price for the information I hope to be able to give you and when I was a "three year old" asked the questions you are now asking of your older brothers. I did not ask them through the columns of Engineering News, a paper I have always revered, but I went to three men who were then about the age I now have reached. They treated me like gentlemen and it was made plain to me that after all each man must answer himself the questions he raises about the future and his prospects. *Kismet.*

I graduated in a dull year from a school of not very high standing. No man in this country who has followed the life of a civil engineer can tell me worse experiences than have fallen to my lot. Many have had as bad but none worse, except mayhap those unfortunate devils who dropped into drink. That one curse, thank God, never attacked me. I have been cheered by the presence of as good a wife as man ever had and my small family is one of which any man might be proud. My work has been varied and in all my travels I was seeking that elusive will o' the wisp "a permanent position." As the years went by and I reached the dead line of age, 35 years, my hopes vanished; and now that the permanent position has come, it came as a surprise. It was totally unexpected but my varied experience has made of me a valuable man to my employers. Few of my jobs heretofore have lasted more than six or eight months. Yet a big bundle of letters proves that I never lost a position through incompetency. My past employers will also tell you that I never left them in the lurch during the last few weeks of the closing up of work, to go to another or to a better job.

The situation is this in the engineering field: An engineering education is the modern educational ideal. That is all. In the early days of civilization, the kings and rulers did not go to school. It was their servants, the clerks and priests who studied. Finally, when life became less strenuous, it became the fashion to send young men to colleges and universities and as their education was never intended to be anything but an elegant accomplishment, no effort was made to give them a course of study different from that given to the priests and literary men. In the present era the aim of all education is intensely utilitarian. Unfortunately for the engineers, a number of young men study engineering simply because education is cheap and they have had such a good time at the high school that they naturally want to put in a few more years having a good time, so they go to college. It happens that their parents insist upon their getting an education they can turn to account after graduation and the majority take the engineering courses.

This is no fancy picture. I have been interested in trying to learn why so many fools enter the profession and so ask every young engineer whom I meet, why he took up the study of engineering. By actual count, 312 have given me the reasons given in the foregoing paragraph. I have no doubt that if every engineer in the country goes at the young men in the manner in which I have gone at them, he will get the same result.

This rush towards the engineering courses is helped by the cheap magazines with their wonderful stories of impossible engineers and contractors. A great many young men who should have taken the literary course at college

take instead the engineering courses. After a few years' experience they discover their error and go into literary work, filling the pages of the low-priced magazines with stories that thrill boys much as military and naval stories thrilled the boys of a few generations ago.

The correspondence schools with their clever and misleading advertising help it along, too. These schools are a Godsend to thousands of young men and a curse to many more. More than the direct harm their advertisements do to the engineers by increasing competition, is the harm they do by making it seem disgraceful for men to work with their hands. Notice the pictures where the young man in his handsomely cut clothes is laying down the law to the laborer and see how the hand workers resent it. They feel their inability to rise to the boss's place and are filled with the idea that the boss considers them inferior. Some of the advertisements are degrading to manhood and should be stopped before the spirit of discontent spreads further in the land.

Whatever the reason, there are more men in the land competent to do engineering work than there is work to be done by these men. The law of supply and demand is inexorable. The pay depends upon the ease with which men may be obtained. It is said that a good man can command his price. It is true provided an equally as good man has not fallen into straits and "needs the money." Too many of the graduates think that because they have studied engineering they should be professional engineers. Bearing in mind that the engineering courses are merely the modern educational ideal, they should banish this idea from their minds and when they leave college seek employment precisely as other college graduates seek employment. Go into any line of business and be sure that at some time or other their modern education will be of value to them. If they are never called on to do engineering work, they have at least had the advantage of the mental training, which is about all the student in the classical courses can be said to have received.

The engineering profession is overcrowded with engineering graduates. They all want to get big pay and believe they should get it because their education cost so much. What difference does the cost of the education make if too many men have paid the price so that necessity fixes the rate of wage? It is a baby-like plea to make. Be honest. Say that after leaving school you were too proud to begin at the bottom at small pay and wanted to begin at a minimum salary of $100 per month with ten-dollar raises every six months. If the boys will leave school determined to hunt for work and do the best they can in whatever position they are placed, the profession will be the gainer. Unfortunately many do this very thing. Many bright young fellows who would be ornaments to the profession do leave it and go to work, leaving the less fit to choke the path that men who love the work have to tread. There are too many mediocre engineers who would have shone behind the ribbon counter or made a success selling merchandise.

My dear "three year old," you are simply up against the wonderful and fascinating problem of life. The methods of Nature are wasteful. Many children are born and many die while babies. It takes many millions of beautiful blossoms to produce only a few apples. Everywhere we see the same forces at work and in engineering the law is not different. Thousands of men will fail for the few who win great success. Yet after all Nature is not unkind. For the man who is careful and competent and makes a minimum of mistakes of judgment there is a sure reward, if he holds out. Study the actuaries tables and see how life insurance rates are fixed. The law of selection is a pretty good law to study. Yet I preach no gloomy philosophy. Nature does hold wonderful rewards for some who can hold out to the end and we are all blessed with Hope. Hope is the greatest blessing received by mankind.

What you have to do is to keep at your work and do it to the best of your ability and try to give your employers value received. If you do, they will notice you. Never look at the clock and do not kick about overtime. If you have made a social engagement and the boss gives you some work that interferes with it, do not show by any expression of your features how you feel. Be pleasant. Do his work and let the party go. Be sure you do not mention the occurrence to any one, either, for it may get to the boss in a badly warped state. Never strike for higher pay. The right kind of a man will give you better pay when he awakes to the idea that other men might want to steal you.

By all means keep away from fellows who are kicking about the impositions an engineer has to suffer. Avoid kickers and growlers as you would the plague. Join good engineering societies and keep away from engineering societies based on labor union ideas. You are a member of a profession, not a day laborer. Your pay may often be less than that of a day laborer but that you can remedy by going into some other line of work if anxious for quick results or you can remedy it by attending strictly to your knitting and after a while your opportunity will come. Then you will find that even the engineering profession has rewards to offer.

Work, read and study. Mingle with men from whom you can derive some benefit. Do not be a toady and hang around big men but do your best to fit yourself to be a man among men and in time you will be taken at your true valuation. It may not be the valuation you put on yourself and it may be a higher one. Suffice it to say that if you seek company among strong men in your own line of work, in course of time they will notice you and it depends upon how you have conducted yourself in their presence, what their opinion of you will be. Do not keep hanging around these men until they notice you and then spoil it all by asking them for a job. There is no surer way of committing suicide. They must not know their company is sought for the purpose of making use of them.

Make your work a hobby but do not talk shop. Learn all you can about your own line of work and read enough about other things to prevent yourself from becoming a bore. Cultivate the art of conversation. This is best done by cultivating the art of asking proper questions. Most men love to talk about the things that interest themselves. Most men are bad-mannered and interrupt in conversation. The most charming conversationalists, you will notice, are the men who, when interrupted, immediately shut up and let the other man talk and never show impatience or annoyance. When conversing with a man who likes to talk they can by adroit questioning get him to talking about himself and his work and make a firm friend of him. When invited to talk about your own work, do so with little waste of words and do not take up too much time. When men interrupt graciously permit them to go ahead. When the conversation has gone to such a length that it would cause an abrupt break to resume the thread where you were stopped, do not attempt to go back, but simply do your part in continuing. Be a gentleman.

Life is like a river and we are like chips floating upon the surface. Some keep in the thread of the stream. Some seem to be always in the rough waters, while others are swept into peaceful eddies. In each state of life much comfort can be found and life is what we make it. Adaptability is what a man requires. The man who can keep consistently in view a great future, provided Fortune favors him and does his best to fit himself to properly enjoy that fortune, is the one to whom it will surely come if death does not step in to end all. There are building and loan associations whereby some men get rich because others tire and drop out of the race. It is with engineers as with physicians and surgeons, lawyers and ministers, business men, kings and beggars. Success comes to him who patiently hustles while he waits, for we must all wait.

Debt will sometimes accompany you on your right hand. At times he will be a mere wraith. Sometimes he will be a most robust presence, sapping your vitality and compelling you to take gloomy views of life. I speak from personal bitter experience. I have had death enter my family when I was out of employment and head over heels in debt. Avoid debt as you would the plague. It leads to deceit and oftentimes disgrace and utter failure. You may overcome this fearful handicap but it means self-denial and hours of distress. But I honestly believe that if a well-educated engineer of robust body possessed of ambition and who is a good mixer, can keep out of debt, there will be no need of worrying about the future. A lady took her son to the most famous lawyer in Great Britain once and asked him if he believed the boy could become a lawyer. "Madam," the great man said, "If your son can eat sawdust without butter for ten years, he has in him the elements that will surely lead to success at the bar."

Finally, my dear "three year old," hold yourself at a right value. Carefully study the prevailing pay for each position held by engineers. Set your mind on getting the ruling pay for each position you hold. The ruling pay is the average, not the highest. If the ruling pay for a certain class of work is $75, take it, if you need the work. Do not ask a man to pay $100 when he can whistle for all the men he wants at $75 and get them. On the other hand, never do for $50 any work you know is generally paid for at the rate of $75. If you need the money, go out in the ditch and earn it by manual labor. Be a fit man and a reasonable man. Look the kickers over. You will find, as I have found, that the chronic kicker is seldom a good worker. The chronic kicker is generally selfish and the "Devil take the hindmost" sort of philosopher. The chronic kicker is generally the worst wage-cutter in existence, albeit he will kick at the wage even while taking it. Get away from kickers and herd with optimists.

All the world loves a lover and you should love your work. The old Psalmist said "Seest thou a man diligent in his business? He shall stand before Kings. He shall not stand with mean men."

If you love your profession and are bound to succeed and so conduct yourself that you are a credit to it and keep out of debt, your future is assured. Never fear. I had my periods of fearful doubt but kept on; and every engineer who is making a living to-day can say the same. I was ambitious to be a great engineer and have fallen very far short of it; but I have reached a state of contentment where my ambitions have centered themselves on my sons, who are both to be engineers. I am hustling for a living; at last fixed in a permanent job at good pay and with opportunities galore to improve my mind for I like study.

If you have stuck to it for three years, you will undoubtedly keep at it. However, it is no disgrace to quit, but is rather an argument showing you possess good horse sense if a good opportunity comes in some other line and you seize it. It is your business to make a success of your life. Finances play a mighty big part and if good opportunities come up, you must take them if they offer you an honest living.

The schools will pour out their graduates. The correspondence schools will do more and more work in starving young fellows out in engineering work and competitive conditions are bound to be worse rather than better in the future. We will see the rank and file getting lower pay and we will see the men at the top getting much better pay than is at present the case.

It is your business to warn the young fellows at school that they alone are to blame for the fearfully hard times they have the first few years after graduation, because they are willing to work so cheap to get the experience. Tell them to insist upon a leveler's pay if they run a level. To insist upon a transitman's pay if they run a transit. To insist at all times upon the ruling pay for the class of work they do.

At present many big companies do nearly all their exploratory work and much of their surveying and construction work in the summer months when they can get fresh graduates to work for less than chainman's wages, simply for the experience.

It should be a part of the duties of professors to warn the boys; but instead we find them solemnly advising the boys to work cheap for a few years for experience sake, yet not warning them about the effects of the cutting of wages. Work cheap if you need the money, but take a cheap job. Do not do superior work for less than ruling pay and thereby hurt your own future.

Yours truly,

'86.

St. Louis, May 1, 1909.

"Sympathy for the Young Engineer" and a Defense of the Engineering Professor.

Sir: Referring to the letter from Mr. J. H. Eby in Engineering News, April 15, p. 418, I think it is time some one put in a word for the college professor.

Mr. Eby, along with a great many other practical engineers, seems to consider that the professors in our engineering colleges know nothing of the practical side of their profession, and that what they teach their students is purely theoretical. He refers to the "take field work of a college course," and speaks of the levelman and transitman on a railroad location party as "looking beside his professors like giants to a pigmy."

I think that if engineers who hold this view of the work of our engineering colleges would look carefully into the matter they would find that there was considerably more practical work done than they had any idea of. Of all the professors of engineering that I know, I can think of none who have not had considerable practical experience.

Of course no one realizes more clearly than the professor the impossibility of turning out a finished engineer at the end of a four years' college course, but at least I can say that I have never known of a student who graduated at the head of his class and then went out into practice, knowing as little about practical work as the young man described by Mr. Eby seems to have done.

Yours truly,

R. B. H. Begg,
Associate Professor of Civil Engineering,
Syracuse University.

Syracuse, N. Y., Apr. 27, 1909.

Notes and Queries.

In the article on the appraisal of the property of the Waterloo (Ia.) Water-Works Co. by Prof. A. Marston, in our issue of April 22, reference was made in a foot-note to a case where an appraisal made on behalf of the city was accepted by the water company, although the latter had no representative on the board of appraisal. We learned, too late for inclusion in the note, that this appraisal was made at Quincy, Ill., in 1903. The foot-note stated that Prof. D. W. Mead, M. Am. Soc. C. E., of Madison, Wis., was one of the appraisers. The other appraisers were Messrs. Hiram Phillips and John W. Alvord, M.'s Am. Soc. C. E. Prof. Mead informs us that the company

furnished quite complete information at the request of the Board, and although in no wise bound by the Board findings, they accepted the valuation as made.

In the description of the ice-jam at Niagara Falls in our issue of last week it is possible that we conveyed the impression that the Gorge R. R. was permanently damaged. We are informed that though the overhead work on the road was almost totally wrecked, the damage to the roadbed was very slight, so that the work of repair can be soon completed and the road in operation by June 1, of this year.

The Undermining of a Reinforced Concrete Retaining Wall Founded on Piles.

On March 4, 1909, a portion of the reinforced-concrete retaining wall holding back one bank of Cherry Creek, as it passes through Denver, Colo., was undermined and so injured that it has become necessary to replace a section some 70 ft. long. From information placed at our disposal by Mr. Charles W. Comstock, M. Am. Soc. C. E., of Denver, we have prepared the following account of the accident. The amount of money and labor involved was small, but the evils incident to insufficient footings and possible undermining in saturated earth are just as evident as though the damage had been greater.

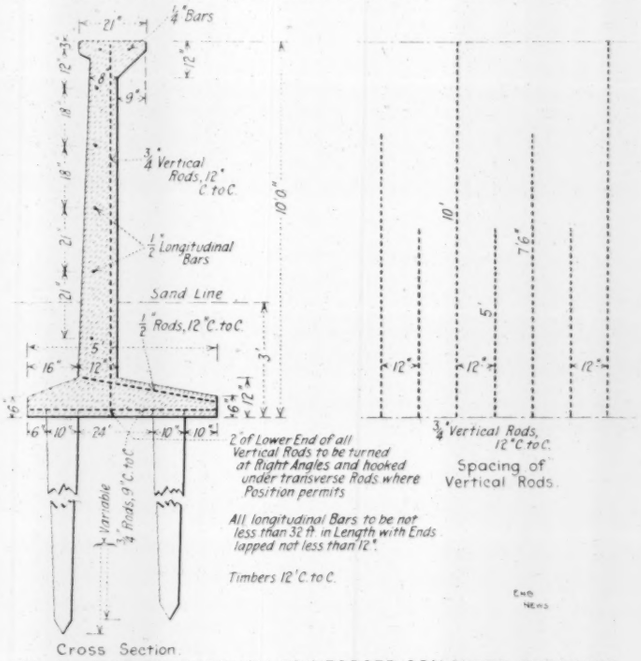


FIG. 1. SECTION THROUGH REINFORCED-CONCRETE RETAINING WALL, CHERRY CREEK, DENVER, COL.

Fig. 1 shows a section through the wall. At other points along the river, a counterforted wall had been built, but in this portion the ribs had been omitted with a view to economy. The wall, however, had been correspondingly strengthened, in its section and reinforcement. All reinforcement is of twisted square rods. The concrete, under examination, shows a hard compact mixture of excellent quality. The hemlock piles varying from 10 to 16 ft. long and of a maximum butt diameter of 10 ins. are spaced in groups of two, 12 ft. c. to c. in the line of the wall.

The bed of Cherry Creek is of sand overlying a thinly laminated clay shale of most irregular surface. At places this shale is visible at the creek bottom and at very short distances away will drop to as much as 25 ft. below the sand level. Just above the point of initial break in the wall, there is one of these changes in level, where a nearly vertical ledge of rock drops off some 8 ft. in a line diagonal to the line of the wall (Fig. 2). During the past winter a dredge had been scooping sand from the creek bottom and dumping it behind the completed wall and by the first of March in working upstream had reached the lower elevation, or downstream edge, of the above noted ledge. The fill behind the wall at this point reached to about the elevation of the top of the wall.

About this time some warm weather started a thaw in the upper portion of the drainage area and caused a small flood in the creek, which, in washing over the ledge was thrown with some force against the retaining wall at the end of the ledge. This wash soon undermined the wall and left it supported only by piles projecting several feet above the sand they penetrated. It happened that one of the front piles at this section was driven only about four feet to the bed rock which was very high at this point. The sand was soon washed completely from around this pile leaving the wall there unsupported. The additional load thus thrown to the adjacent piles crushed and shattered their tops so that the wall sagged about two feet in the middle of the washout. The top of the wall swung three or four feet out of line toward the creek, but was held from complete collapse by the longitudinal reinforcement. It remained in this condition until removal previous to the reconstruction. The accompanying Fig. 3 shows the break after the damaged portion had been removed. The wall weighed about 1,800 lbs. per lin. ft. and the earth filling on the base added about 3,000 lbs. more. It is probable, from the appearance of the wall on either side of the break (Fig. 3), that the horizontal thrust was sufficient to throw all of the load on the outer, or creek side piles, in which case each of these piles was carrying about 29 tons. When the short pile noted particularly failed, the adjacent piles must have carried about 43 tons each, a load that would account for the shattered tops.

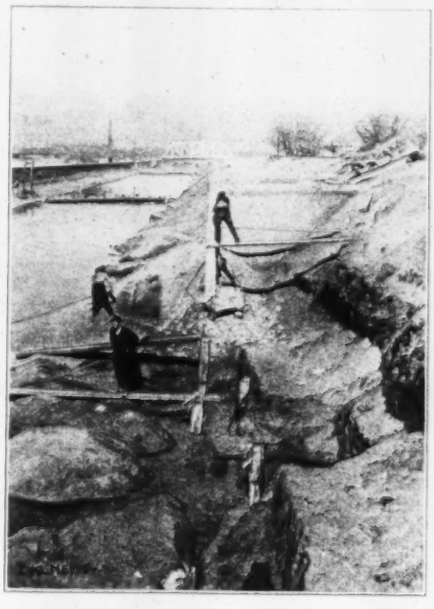


Fig. 3 Break in Retaining Wall Looking Downstream or West

FIG. 2. LEDGE IN BOTTOM OF CHERRY CREEK.
(Water is 4 ft. deep, dry bottom shown 3½ ft. above water, making ledge 7½ ft. deep.)

Valedictory Dinner to Prof. George F. Swain.

Former students of the Massachusetts Institute of Technology joined in a complimentary dinner to Professor George F. Swain at Boston on the evening of April 30. Prof. Swain, who leaves the Institute shortly to become Professor of Civil Engineering at the new Graduate School of Applied Science at Harvard University, has been on the faculty of the Institute continuously for 28 years, beginning in 1881 as Instructor. In that time he has earned the esteem and affection of all who studied under him, in an unusual degree, and the dinner resulted from a desire to give expression to this appreciation. Some 75 men gathered around the tables. Addresses by prominent graduates of the Institute told of the sentiments of Prof. Swain's fellow-students and pupils toward him. The speakers included:

The toastmaster, Mr. J. Waldo Smith, Chief Engineer of the Board of Water Supply, New York City; Mr. Charles A. Stone, '88, member of the Corporation of the Institute and member of the contracting firm of Stone & Webster, Boston; Prof. Alfred E. Burton, Dean of the Institute; Mr. Charles T. Main, '76, of the engineering firm of Dean & Main, Boston; Mr. George W. Kittredge, '77, Chief Engineer of the New York Central & Hudson River R. R.; Prof. William Z. Ripley, '90, of Harvard University; Prof. Charles M. Spofford, '93, who is to succeed Prof. Swain at the Institute; Mr. Frank L. Locke, '86; and Prof. Swain himself.

The toastmaster, after expressing regret that Prof. Swain is to leave the Institute, said:

> Harvard University has chosen wisely in selecting one who has been such an inspiration to his associates as well as to his students. I have never known any one who could so well bring out the best that there is in others. He has left his mark on every work that he has undertaken: in his study of water powers for the Tenth Census of the United States; in his work of teaching; as an engineer of the Massachusetts Railroad Commissioners; as a member of the Boston Transit Commission and of various other committees and commissions, including the National Conservation Commission of which he is now a member; and as president of several engineering and educational associations and societies.
>
> My acquaintance with Prof. Swain dates back 27 years, to the time when he returned to the Institute as an instructor. From the beginning it has been evident that he has made a study of human nature, and that he recognized the possibilities of his students in many cases far better than they did themselves.
>
> It has been too often the case that engineers have stopped with making or carrying out plans for strictly engineering work. The engineer, however, ought to be the man of all best fitted to supervise and manage large industries and undertakings. Many such projects now come under the control of politicians. In my experience most politicians are honest men, but need and would welcome competent advice such as well-trained engineers are able to give them. I believe that engineers should take a much more prominent part in public affairs and in

the management and control of public works. The great problem of municipal government must be worked out in the future by the engineer.

Mr. Stone, speaking as a member of the Corporation of Massachusetts Institute of Technology, told how, when the executive committee heard that Prof. Swain meant to resign, he had been delegated to urge him to reconsider. He had found Prof. Swain fixed in his determination, however, and fully convinced that the best interests of himself, of the Institute and of Harvard made the change desirable.

Prof. Burton spoke as an old associate, having joined the faculty of the Institute in 1882, a year after Prof. Swain. He referred especially to Prof. Swain's ability to maintain a high standard of work among his students, and to his influence, in the faculty, toward progress and toward advancement of the Institute, its courses and its methods. He remarked that it would not be a compliment to Prof. Swain to anticipate that, of all the structures he has designed and built, the greatest—the Institute's Civil Engineering department—would fall down on his departure.

Mr. Main and Mr. Kittredge, fellow-students of Prof. Swain, eulogized his excellence as a student. Mr. Kittredge remarked that, though the youngest of his class, Prof. Swain had been so far above the rest as to be virtually in a class by himself, and yet there never was any jealousy on the part of his classmates.

Prof. Spofford and Mr. Locke, students under Prof. Swain, spoke of his work as a teacher. Prof. Spofford said:

At the time when Prof. Swain returned to the Institute as an instructor, no man in the country was better fitted by training, education and ability to teach structures than he. The work of bridge design was then largely in the hands of bridge company engineers who were not thoroughly grounded in the theoretical side of the work and they naturally followed the lines of least resistance as indicated by previous practice. Prof. Swain's great work has been to show that correct theory and good practice always go together. During the early years of his teaching there were few students, little money available, and no suitable corps of assistants. In later years, however, the growth of the department has enabled him to devote most of his own time to instruction in the subject of structures. How well he has done this is well known to engineers and needs no further testimony from me.

Within the last few years it has been my fortune to see a good deal of the work of men trained in various engineering schools and I have found that Prof. Swain's students have been far better trained in clear and concise thinking and in the broad principles of structural design than those from other schools. Prof. Swain never was satisfied with teaching structures alone, but continually preached broadness of training and showed his students how to reason clearly and arrive at sound, honest conclusions. I believe that such a training as a matter of mental discipline would be as valuable to the young lawyer or divine as to the engineer.

But the most interesting, perhaps, were the remarks made by Prof. Swain himself in thanking his friends for their expressions of appreciation. In particular, he set forth his reasons for leaving the Institute for a new sphere of work:

My work at the Institute has been a great pleasure to me. When I came here as an instructor in 1881, Prof. Vose was at the head of the department, and I was the instructor; we were the whole teaching corps of the department. The first class to graduate after my return, in 1882, comprised but two students; the next year there were three, and the growth has been practically continuous since that time. Now the graduating class from the Civil Engineering Department numbers about 75 students. The engineering library, which in the beginning filled but one small bookcase, has grown similarly, and is now, I believe, the best engineering library in the United States.

With this growth have come a great many problems, both in teaching and administration. With small classes it was possible to give a great deal of individual and personal instruction. With the large classes, this is not possible, and a division of the class into sections results in a great deal of repetition and routine work which is very wearing upon a teacher.

You are doubtless all asking why, after so many years at the Institute, I am willing to leave and go to another school. This is a fair question and shall have an answer. There are three principal reasons:

First: Change is a good thing, both for individuals and for institutions. We all get into ruts, and an occasional change is probably a help to every one.

Second: The changes in methods of instruction which are necessitated by the great increase in the size of the institute are not congenial to me. The amount of routine work is too great and it has become impossible to give the individual instruction which I believe is the best and most effective method of teaching engineering students. To those who believe in the lecture method, large classes are no drawback, but I do not think that this is the proper method to follow in engineering subjects. In my new field of work, the school being a strictly graduate school, I will deal with much smaller classes. While I regret that I shall not come in contact with so many men, I feel strongly the great need of doing more intensive work, which will be possible in the graduate school.

Third: Most important in my estimation, I believe that the work which the Harvard Graduate School of Applied Science is entering upon will do a great deal to advance the standing of the engineering profession. It is undoubtedly a fact that engineers do not receive as much respect as the members of the older professions. Corporations are frequently willing to pay large fees to lawyers, but grumble over paying much smaller ones to engineers. It seems to me that the position of the profession depends upon three factors: First, the inherent importance of its work; second, the standing of its members in the world, and third, the amount of training required for the practice of the profession. Nobody can deny that the work of the engineer is as important as any, but so is that of many a man who is not engaged in professional work. The standing of the members of the profession in the community depends in very great measure upon their training and breadth of view, which brings us to the third point, the amount of training required for the practice of the profession, as the one of prime importance in fixing the standing of the profession. In these respects the engineering profession has always occupied a lower place than law, medicine, and theology.

The engineer is in general respected more for his skill than on account of his capacity or the power of his brain, and in this is classed much the same as a skillful mechanic. It seems to have been generally admitted that no such extensive training is necessary as for the practice of the older professions. The first engineering school in this country was established in 1824, when there were several schools of law and medicine, and although the standards have been gradually raised, the four-year course is still considered all that is necessary for the practice of engineering, while our best schools of law, medicine and theology are all graduate schools, requiring a college degree as a preliminary.

In making its engineering school a post-graduate school, I believe that Harvard has taken the greatest step that has yet been taken to raise the dignity of the engineering profession. I do not feel that I could decline an opportunity to be connected with the first graduate school of engineering in this country, and one in which so great a work was to be undertaken.

This school will occupy a somewhat different field than that of the Institute. I believe that there should be no conflict and that there will be the heartiest cooperation. Harvard has left to the Institute the larger field of the four-year under-graduate course in engineering, which will always attract the largest number of students. Of course the graduate school does not always get the best men, and in the same way in some cases the best men do not get any college training, but I firmly believe that the very best educational training can be given and can only be given in a graduate school.

We regret that lack of space prevents us from giving a list of the engineers, educators and business men who made up the company on this notable occasion.

Lock No. 3, Cumberland River.

By WILLIAM W. HARTS,* M. Am. Soc. C. E.

The recent completion of Lock No. 3, Cumberland River, has served to draw attention to the progress being made toward the canalization of that stream. The project of improvement contemplates the canalization of the river from its mouth in the Ohio, at Smithland, up to the confluence of its two forks in the neighborhood of Burnside, Ky., a total distance of 517.8 miles. The principal city on the river is Nashville, Tenn., and it was to facilitate the handling of traffic to and from this city that the system of improvement was undertaken. With this in view work was commenced at Nashville, with the intention of extending it both up and down stream until completed.

The earlier projects for improving the Cumberland River by means of wing dams and dikes to provide for open-river navigation, although successful within the limits of their possibilities, did not give sufficient promise for year-round navigation, and the system of canalization was therefore adopted, about 1886, in order to furnish adequate transportation facilities to the agricultural regions east of Nashville, which at that time had no railroad connections, and to open the river connection with the Ohio for year-round commerce.

It was deemed best to commence the upstream portion first, and accordingly seven locks and

FIG. 1. LOCK NO. 3, CUMBERLAND RIVER, FROM BANK ABOVE LOCK.

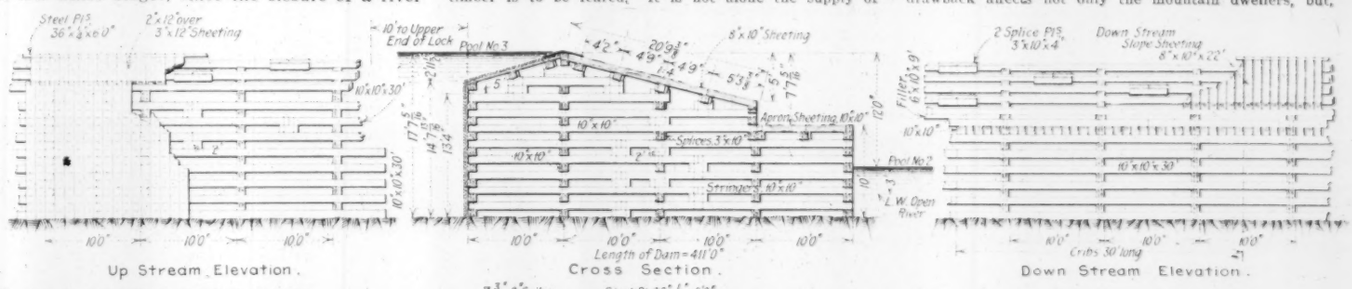
dams were decided upon for the improvement of the river from Nashville to Carthage, at the mouth of the Caney Fork. It was thought that when these were completed it would be plain whether the increased navigation and development of commerce would warrant the extension of the plan to Burnside by the construction of the remaining 15 locks required in that distance. In order to provide needed boating facilities at Burnside, where the Queen & Crescent Ry. crosses the river, it was later decided to build Lock No. 21, which is now under construction. This will furnish a pool for mooring or storage during low water, and create a small harbor near the railroad connection.

The locks below Nashville are designated by letters; those above by numbers. Locks 1 to 7, inclusive, have been under construction for many years, work on the first lock having been commenced in 1888; but the carrying out of the project has been greatly delayed by the lack of sufficient and timely appropriations. At the present time, however, the masonry for all seven locks has been completed; the gates have been hung at all except two, and at these they have been delivered ready for erection during the coming season; and the dams have been completed at three of the sites and partially built at one of the others. Work will be undertaken this season on two of the remaining dams.

*Major, Corps of Engineers, U. S. Army, Nashville, Tenn.

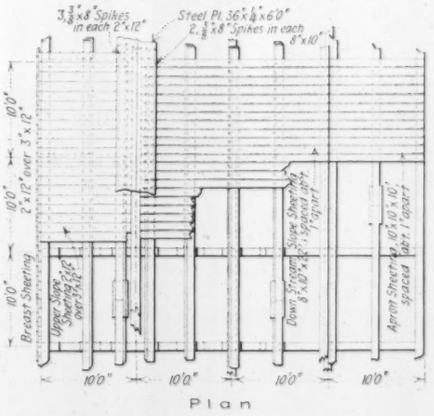
In the series below Nashville, one lock and dam, "A," has been completed and in operation for about four years. All these locks are built of cut stone masonry, and have steel gates and timber-crib dams with sloping tops.

The masonry for Lock No. 3 (Fig. 1) was commenced in May, 1893, and completed in March, 1895. The gates were hung in August, 1908, and the dam was completed and the lock opened for navigation in November. The masonry walls of the lock were built by hired labor, at less cost and in less time than similar ones built by contract. The lock, abutment and dam are founded on rock. The dam (Fig. 2) is a double-slope, timber-crib, rock-filled structure, the construction of which required the concentration of effort at low-water stages, since the closure of a river must be accomplished at the period of least flow. All the materials for the dam were collected and ready when the time came for its construction, so that the work of erecting it required but about six weeks' time.



Up Stream Elevation. Cross Section. Down Stream Elevation.

The dam is to be filled with broken stone.
Pens of dam to be 10 ft. c. to c. lengthwise of dam.
Timber to be long-leaf yellow pine, 10 × 10 ins., unless noted.
Blocks all 2 ins. long, unless noted.
Lower slope and apron sheeting to be laid with gaps of 1 in. between successive pieces.
Lower slope sheeting to have one 16-in. drift bolt at each stringer.
Apron slope sheeting to have one 18-in. drift bolt at each stringer.
Upper slope sheeting 3 ins. thick to have two wrt. boat spikes ⅜ × 6 ins. at each stringer.
Upper slope sheeting 2 ins. thick to have two wrt. boat spikes ⅜ × 8 ins. at each stringer.
Breast slope sheeting 3 ins. thick to have two wrt. boat spikes ⁵/₁₆ × 5 ins. at each of three stringers as shown.
Breast slope sheeting 2 ins. thick to have two wrt. boat spikes ⁵/₁₆ × 7 ins.
Steel plates 36 × ¼ ins. × 6 ft. to have three ⅜ × 8-in. spikes at each 2 × 12-in. and two ⅜ × 8-in. spikes in each 8 × 10-in. piece.
Timbers to have at each intersection and at each end one 18-in. drift bolt, unless noted.
Stringers in upstream face to break joints at center of pen and be fastened to 2-ft. block below with one 28-in. drift bolt.
Stringers to be 30 ft. long.
Ties to be 16 and 24 ft. long, as shown, unless noted.



Plan

The following is a detailed statement of the cost of the lock and dam:

COST OF LOCK AND DAM NO. 3, CUMBERLAND RIVER.

Land for lock and abutment	$2,578.93
Lock (including excavation for foundations, cofferdam, pumping, temporary buildings and delays and loss due to floods and interruptions from lack of funds), 11,242 cu. yds. stone masonry, at $15.74	176,966.68
Abutment (including forms and cofferdam), 1,643 cu. yds. of concrete, at $7.14	11,733.50
Guard wall (including cofferdam, pumping, forms and excavation), 907 cu. yds. concrete, at $8.28	7,511.96
Bank protection (including grading, quarrying and transporting rock)	18,476.14
Dam	25,574.20
Gates (about 210,000 lbs., at approx. 7½ cts.)	15,869.21
Valves, maneuvering appliances, etc.	3,424.49
Excavation of lower approach, 13,950 cu. yds., at 13.8 cts.	1,925.37
Total	$264,060.48

COST OF DAM IN DETAIL.

Excavation, 3,745 cu. yds. gravel and sand, at 7.34 cts. per cu. yd.	$274.81
Cribbing:	
Lumber, 429,121 ft. B. M., at $28.57 per M. ft.	12,261.87
Framing and placing, at $6.17 per M. ft.	2,648.22
Plates, nails, boat spikes and drift bolts (about $2.92 for each M. ft. of lumber)	1,254.19
Rock fill:	
Rock quarried, 3,563 cu. yds. (solid measurement in place), at $1.20 per cu. yd.	4,288.93
Royalty, 3,563 cu. yds., at 5 cts.	178.15
Towing, 3,992 cu. yds. rock, at 40 cts.	1,596.80
Placing, 3,992 cu. yds. rock, at 66 cts.	2,627.75
Earth backing:	
Sand and gravel, 5,320 cu. yds., at 8.34 cts.	443.48
Total	$25,574.20

Opinions of Foreign Engineers on the Value of Forests for Preventing Erosion.*

Authorities are pretty well agreed—indeed, they may be said to be almost unanimous—as to the desirability of protecting the forests on steep mountain slopes in the interests of navigation. At the Tenth Congress on International Navigation, held at Milan, in 1905, this question was discussed, and the reporting engineers were unanimous as to the benefits of the forests. As this foreign testimony may be of interest in connection with this discussion, showing as it does the dependence of the interests of navigation upon the preservation of the forests, it may be worth while to give extracts from some of these reports.

Mr. Lafosse, the French delegate, says:

If the destruction of forests is to be deplored, it is most of all on the mountain that the cutting away of timber is to be feared; it is not alone the supply of the springs and the discharge of the streams which are in danger. It is the very existence of the rivers themselves. The stream which can be utilized disappears to give place to the devastating torrent.

The soil swept bare of its forests, exhausted by the abuses of grazing, loses quickly its vegetable stratum. Washed periodically, and carried away by melting snow and summer storms, it is soon disaggregated. The waters run toward the low points, rolling before them gravel and boulders, and even tearing out loose sections of rock. A thousand rivulets cut out beds, the torrent is formed. Scours begin, the banks are broken down and a mass of mud, stones and rocks invades the valley, destroying everything as it passes.

Mr. Wolfshutz, a delegate from Austria, while admitting that excessive floods are not appreciably checked by forests, writes as follows:

For economical reasons re-afforestations will have to be confined to the steeper mountain slopes which are of little use for other cultivation. Here the forest will have a beneficial influence by making the soil firmer and more compact and by preventing erosion and washing down, and thus any excessive alteration and the formation of detritus which would shoal and silt up the water courses. Such forests further retard the melting of the snows in spring and lessen the violence of spring high water. It is thus advisable in the interests of navigation to spare and to attend to the forest. There is no simpler, cheaper, nor more effective means for securing the mountain slopes and for keeping the pebble shoals down. In this respect, forests have incontestably had a beneficial influence upon the floods of the large rivers. Beyond this however, no further measurable influence upon the high water of rivers can be credited to them.

As regards the occurrence of high floods in the large rivers, the forests cannot have any noteworthy influence. As regards the increase in the ground-water level and in the replenishment of springs the forests have, in the plains, no more influence than the open ground, and it is only in the mountains that this action can be rated at any higher figure. In the mountains, however, the main office of the woods will be to prevent the denudation and erosion of the surface, the formation of detritus, and the silting up of the river beds with mud, sand and pebbles.

Mr. Riedel, of Vienna, is very emphatic as to the benefits of forests. He shows the terrible results which have been brought about by their destruction in various parts of Europe, and with reference to Germany, states that . . .

In Germany also reasonable bounds were not everywhere kept to, and the effects of the progressing deforestation made themselves apparent, on the one hand in scarcity of timber, and on the other in the impoverishment of perennial springs and the alarming lowering of the mean water level of German rivers, and not less so in a gradual increase in the dryness of the ground, caused by the fall of the level of the underground waters.

The unquestioned circumstance, that a large number of rivers now carry down more loose material than formerly, is a consequence of the extensive denudation and careless clearing of the plantations. The slopes of the hills lose a large part of their fruitful soil, and in many cases earth slides, and even extensive subsidences of whole slopes, take place, while considerable areas of ground in the valleys are smothered up and rendered useless.

The loose material which the tributary brooks carry into the main streams, ceases to be carried onward as the declivity becomes less steep and in consequence fills up their beds. The streams are then obliged to seek out new courses, by which the most fruitful ground is devastated and the whole bed of the valley is gradually transformed into a barren layer of loose stones. This drawback affects not only the mountain dwellers, but, in so far as the waters are not able to deposit their loose suspended material in large basins on the way, the population of the lower-lying fertile and well-tilled valleys also. Here the damages further include the circumstance, that, by reason of the often elevated position of the river bed, overflow waters are very difficult to get rid of.

Proofs of the foregoing, and especially of the last mentioned circumstance, are afforded by a large number of river valleys. This condition of things is of importance in the cases of those river or stream channels which, by the formation of weirs, are to be made serviceable for purposes of inland navigation. Thus on the canalized Oder between Cosel and Breslau, properties which, though at a distance from the channel, lie at a lower level than the latter, are swamped to the most damaging extent.

The foregoing is not intended to convey the idea that, previous to de-forestation, earth slides, damages to river banks, and inundations did not take place, but it is intended to show, that since the decrease of the forests all these disadvantages have increased to a serious and disquieting degree.

Mr. Lauda, of Vienna, compares two similar watersheds of about the same area in Austria, one being much more heavily wooded than the other. He thinks the forests may not exert much influence in high floods, but concludes as follows:

If now the final judgment on the subject of the influence of forests on the regimen of streams be unfavorable to the forest to this extent, that there are denied to it certain of the properties attributed to it generally, it does not follow from this that it is necessary to oppose the re-wooding of arid surfaces, the replanting of the basins of streams or the maintenance of plantations of trees. The general utility of the forest is so well settled, the extraordinary appreciation in which it is held, as a means of protecting the soil against landslides, is so firmly established, its great advantageousness especially for the spring district, in holding back earth thrusts and reducing the amount of sediment carried by rivers so important, that these reasons alone justify fully the greatest possible promotion of forest culture.

Mr. Ponti, of Italy, seems to have no doubt that forests on steep slopes are useful in the interests of navigation. He says:

In Sicily, the consequence of cutting away the forests on a vast scale in the province of Messina has been also to raise sensibly the bed of the streams, and many of these beds are now above the adjoining fields.

Mr. Keller, of Austria, thinks that forests affect the regimen and discharge of rivers only to a slight extent except in mountainous regions, regarding which he says:

However, there is no doubt that in many cases deforestation has contributed to the erosion of the mountains and to the deposit of the soil at their foot as also to an unfavorable change in the conditions of flow and drainage of the waters. This remark applies equally to the region of high mountain ranges as to the Mediterranean basin. There also the formation of a cohesive soil takes too long to make good the loss caused by a sudden shower.

*Extract from a paper on "Conservation" by Prof. Geo. F. Swain, read April 28 before the National Association of Cotton Manufacturers.

Mr. Lorentz, of Prussia, does not discuss particularly the effect of mountain forests, but among his conclusions is the following:

(1) Forests form a beneficient factor, acting favorably on the general abundance of water in a country, and particularly on the supply of streams and rivers. That is why the destruction of forests should be considered as hurtful and dangerous.

These extracts show that foreign authorities are unanimous as to the benefits of forests upon the mountains upon the flow of streams and the interests of navigation.

Finally, we have the experience of other countries to guide us in this problem. Almost all the countries of Europe have learned by experience to value and preserve their forests not only as sources of timber but in the interests of navigation. The French government, 70 years ago, entered upon a national policy of forest protection and reforestation, particularly in the mountain regions, which has been continued up to the present time. Up to Jan. 1, 1900, the state had acquired over 629 square miles, for the purpose of controlling torrents. Of this area, 440 square miles are in the Alps, 145 square miles in the central plateau and the Cevennes, and 44 square miles in the Pyrenees. The expenditure has been as follows:

For acquisition of land	$5,200,000
For work of reforesting	4,000,000
For work of regulating	2,900,000
Miscellaneous	1,600,000
Total	$13,400,000

At first there was great opposition to the French Government's policy, on the part of the inhabitants of the mountain districts, and in 1864 there were riots in some places. This opposition, however, has entirely subsided, the inhabitants now cooperate heartily with the government, even petitioning to have it extend its work, and in some cases even giving portions of their lands on the mountain sides without compensation.

Other countries which are working out comprehensive plans for the protection of the forests at the headwaters of mountain streams are England in India, Switzerland, Austria-Hungary, Norway, Sweden, Denmark, Russia, Roumania and Japan.

Let us not be discouraged, therefore, in our efforts to secure government action in this important matter. Let it not be said of us that we have been unable to profit by the experience of others, but have had to learn by dear experience the same lessons which they have learned and which we might have learned from them. Let us also try to realize the enormous waste which is going on in our national resources, and aid by our influence and example in putting a stop to it.

And, finally, let me call your attention to the fact that in connection with this matter the engineer occupies an important position. As the man who directs the great sources of power in nature for the use and convenience of man, it should be his work to devise the means of restricting the waste of those resources. The dependence of our prosperity as a nation upon the engineer as a professional man should be better realized. His advice should be sought in increasing degree by the nation, the state and by the people. In this way the benefits of scientific training and discovery will be directed to this problem, and it is not impossible that new methods and discoveries may be brought to light which will largely reduce our enormous waste and make the prospects for our descendants more cheerful. Most important, however, is it that we should at once check useless waste, and endeavor to realize that the demands of our duty to those who are to follow us are immediate and imperative.

PHILIPPINE COAL was used during the fiscal year ending June 30, 1908, to a very considerable extent by Government vessels. Its efficiency is less than that of Australian coal, but its low price makes its use economical. The coal is obtained from one mine in Baton, Alkay, the output of which does not exceed at present 60 tons daily. It is hoped that in the near future the daily product will be increased by several hundred tons and that the quality will improve as the mine is developed. Adjacent to the mine the U. S. Army is developing another deposit which bids fair to produce large quantities of very good coal. At Danao, near Cebu, considerable capital has been invested in the development of coal fields and there are great hopes that in the near future coal for most purposes will be produced in sufficient quantities to meet the demands of local consumers.—Annual Report of the Philippine Commission for 1907-08.

STREET-CAR FENDERS AND WHEEL-GUARDS must be installed on electric street-cars in New York City, according to an order just issued by the Public Service Commission. For some parts of the city only wheel-guards are specified, for others only fenders, and for some parts both wheel-guards and fenders. Drawings and specifications of the devices which the companies desire to install must be approved by the Commission, and the devices must be installed within a few months.

The White Man's Burden in the Sanitation of Manila.*

Lately there has been considerable disposition to make comparisons between the city of Manila and the modern well-regulated cities of the United States. Surprise is expressed that the cleaning of the *esteros*, the draining of certain large districts, and the general sanitation of the city has not been accomplished. True, there is considerable sanitary work to be done in Manilla, but the same may be said of any large city of the world more than 50 years old. What seems to be forgotten is that Manila covers an area of more than 12 square miles, most of it only a few feet above tide water, that the city is some centuries old, and that its drainage, the raising of its level, and the correction of its sanitary defects can hardly be accomplished between two days.

The American Government has been in the Philippines a little more than ten years, some three of which were devoted to warfare and the suppression of public disorder. Before damning the government because everything has not been done, it might be advisable to stop a moment and compare the condition of Manila on Aug. 13, 1898, with its condition on June 30, 1908. Prior to American occupation Manila never had a sewer system, never had a drainage system, never had an adequate supply of potable water, nor any supply, until Carriedo, a noble Spaniard, furnished the means to construct the water system now in use.

From the time that Manila was a village—and that was a long time ago—until the year 1902 the filth and nastiness of certain districts found their way into the moat or into sluggish *esteros* that meander through the city. From time immemorial until some six years ago the filth of the *nipa* districts, which cover a large area, was either deposited under the dwelling or carelessly distributed over the neighboring landscape.

As a temporary measure of relief from these conditions public midden sheds were constructed in 76 different localities and a pail system was established. No one ever considered these measures as anything but temporary; and every one knows, or should know, that no adequate or permanent relief can be expected until a plentiful supply of fresh water is brought to every door and a proper sewer and drainage system has been furnished to Manila.

One of the very first works undertaken under the American regime was the preparation of plans for an adequate supply of fresh, clean water and the construction of a modern sewer system.

The Philippine government is the poorest in financial resources of all the governments of the civilized world. Its net revenue for the fiscal year 1908 for all insular, provincial and municipal purposes was $1.91 per capita. Porto Rico, Bulgaria, Servia, all have more money per capita than the Philippines. Compared with the insular government, the Cuban Government is a millionaire ten times over.

Nevertheless, the citizen and resident of the Philippines, like the citizens and residents of other countries, is disposed to ask for all kinds and classes of public improvements, which cost money and plenty of it. When asked to pay the taxes necessary to meet the cost, however, he is just as free in his denunciation of the tax as he was of the lack of the improvement. Every measure that has been undertaken for the protection of the health of the people and to secure them against contagious diseases has been bitterly fought, opposed, and resisted by those for whose benefit the measures were primarily intended. Every medical man who has been charged with responsibility for the public health has been compelled to walk unshod to his goal over the thorny road of criticism, denunciation, and calumny. No health ordinance meant to protect the people from disease and contagion has been proposed but that a concerted attempt to emasculate and destroy it has been initiated by the very people most to be advantaged by its passage.

Even as late as the last session of the Philippine Legislature a determined effort was made to do away with the health districts of the city of Manila and to reduce the number of medical men who are charged with the duty of remedying, as far as possible, unsanitary conditions and unsanitary methods of living.

Every endeavor to oblige the property holder to tear down the squalid hovels used as habitations by the poor and to erect decent buildings of light materials for his tenants has been stubbornly resisted and made the subject of denunciation by the agitator and mountebank, who found therein a veritable mint of political capital.

Sanitary measures, sanitary information, regulations for the suppression of epidemics, respected throughout the scientific world as founded on sound sense and right reason, have been combatted, opposed, and denounced as foolish in the Philippines. The creation of public parks, the maintenance of beautiful lawns, the establishment of breathing places for the people, and the purchase of land for these purposes have been condemned as wanton extravagance and as a woeful waste of the public moneys. The demagogue and the conscienceless politician have on countless occasions demanded the resignation of the director of health and the secretary of the interior when they sought to enforce well-recognized and established sanitary measures. And now they are no less vigorous in joining the outcry because cholera has not been suppressed in a few days, a disease which has existed in the Philippines and in the city of Manila, as shown by the records, since the year 1817—a disease, by the way, whose existence was frequently denied by these very same demagogues and political hacks in the teeth of the declaration of able doctors and able scientists, respected for their learning and attainments everywhere except in the Philippines.

The bureau of health, the municipal board, and the department of sanitation of the city of Manila have encountered the same opposition here to health measures which is offered to modern sanitation in every oriental country with the exception of Japan; and that these departments of the Government have accomplished so much for the health of the city and the betterment of sanitary conditions entitles them to the highest commendation and praise. If things have been left undone, they have been left undone because all things cannot be accomplished at once. If there has been negligence here and there in the inspection of dwelling houses, let that be attributed rather to the personal equation than to incompetency of important departments or bureaus. These departments and bureaus of the Government are entitled to be judged by the results achieved, and he is indeed a lying critic who will say they have accomplished nothing.

The reduction of the death rate in the city of Manila, the keeping of the cholera within bounds whenever it has made its appearance, the stamping out of plague, the reduction to reasonable proportions of smallpox, which in 1898 was almost a common disease, say something for the men and the officials who have labored so earnestly and so efficiently in the face of great difficulties and without the hope of even common gratitude.

*From the Report of James F. Smith, Governor-General of the Philippines, in the Report of the Philippine Commission to the Secretary of War, 1908.

A POWDER MILL EXPLOSION in the glycerine packing house of the Potts Powder Co., at Reynolds, Pa., April 29, caused the death of four men.

A TRAIN OF DUMP CARS IN PANAMA was wrecked May 1 on the Gold Hill section of the canal and eleven workmen were killed. The accident is ascribed to the release of the brakes before the locomotive was coupled to the cars, which rolled backward downgrade and, leaving the track, fell to a lower level of the cut.

A MOST DESTRUCTIVE WIND STORM, first reported in Kansas April 28, swept southeast through Arkansas, western Tennessee and northern Mississippi and passed out to sea off the coast of Georgia May 1. In addition to an immense property loss, the storm caused the death of about 200 persons in the states named.

High winds in Missouri, Indiana, Wisconsin, Illinois and Ohio April 29 and 30 did considerable damage to buildings and many deaths were reported. Six persons were killed by the storm in Pittsburg, Pa., April 30, and several buildings were unroofed in Philadelphia on May 1.

THE PATHFINDER DAM, which has been under construction on the North Platte River, Wyoming, since September, 1905, was completed on May 1, 1909. The dam was built by the U. S. Reclamation Service, with the Geddis & Seerie Stone Co., Denver, Colo., as contractors. The dam is a concrete-rubble arch, 215 ft. high, built in so narrow a gorge that its top length is only 500 ft. The dam impounds water from a drainage area of some 12,000 sq. mi., in Colorado and Wyoming, and forms a reservoir with a capacity of 1,025,000 acre-ft., or 358,000,000,000 gals. The dam is named after Capt. John C. Fremont, the pioneer and explorer, who lost his equipment at this point while trying to pass through the gorge in a boat. Over 250 miles of the old "overland trail" to the California gold fields passed through the area included in the North Platte Project, as the irrigation works which include this dam are called. A railway now extends the entire length of the project area. The accompanying comparative figures, relating to the Pathfinder Dam and three large eastern dams, have been given out by the U. S. Reclamation Service (F. H. Newell, Director; A. P. Davis, Chief Engineer).

Dam.	Height, ft.	Length, ft.	Contents, cu. yds.	Cost.	Storage Capacity, acre-ft.
Pathfinder	215	500	60,400	$1,200,000	1,025,000
Wachusett	228	971	273,000	2,226,000	192,000
New Croton	297	1,072	833,000	7,631,000	92,000
Ashokan	220	*4,800	a7,900,000	12,700,000	308,000

a500,000 cu. yds. of masonry and 7,000,000 of earth.
*Masonry, 1,000 ft., and earth work, 3,800 ft. This dam is now under construction by the Board of Water Supply, New York City. [The new Croton Dam was built by the Croton Aqueduct Commission, for New York City, and the Wachusett Dam by the Metropolitan Water and Sewerage Commission, for Boston and vicinity.]

Articles on the Pathfinder Dam were published in our issues of Aug. 10, 1905, and Oct. 29, 1908.

A TENEMENT HOUSE FIRE on Spring St., in New York City, April 30, resulted in nine deaths, six of the victims being children under eight years of age. The building was a five-story structure with stores on the first floor. The fire was of incendiary origin and spread rapidly owing to the kerosene flung about the halls by the incendiaries. The fire is attributed to the Italian "Black Hand."

THE SPOKANE, PORTLAND & SEATTLE RY. was opened for transportation May 3. On that date, according to an announcement issued by the Northern Pacific Ry., through trains were placed in operation over the new road between Spokane and Portland. The construction of this railway, which was formerly known as the Portland & Seattle Ry., was described in Engineering News for Feb. 13, 1908.

RAILWAY CONSTRUCTION IN CANADA.—In 1888 Canada had open for traffic 12,200 miles of railroad line. In 1908 there were being operated 23,000 miles of line. During those 20 years the Dominion Parliament granted 203 charters; authorizing some 63,000 miles. This does not include charters granted the four large Canadian companies, the Canadian Pacific, Grand Trunk, Grand Trunk Pacific and Canadian Northern. Of the total number of companies incorporated only 25 have constructed any portion of the lines authorized and 86 charters have lapsed. Of the remainder 88 have been given one extension of time, 42 have received two extensions and 18 have received three or more extensions. Since 1900, 117 charters have been granted, covering 25,000 miles, of which only 400 miles have been constructed, while the four big companies have built almost 4,000 miles in the same period. It looks very much as if independent roads are not likely to be encouraged by the Dominion Government at future sessions.

MULTI-DOOR CARS IN THE NEW YORK SUBWAY are progressing slowly. An eight-car train built according to Mr. B. J. Arnold's proposal with separate entrance and exit doors at each end of the car was tried for some days recently. The result was a pronounced difference of opinion as to whether or not it had proved successful. The engineers of the Public Service Commission asserted that it was highly successful, while the officials of the Interborough Rapid Transit Co. claimed the train proved a failure. The company had continuously maintained a determined hostility to any suggestion for more doors in the subway cars. After the trial there were more or less definite accusations that the officials had "fixed" the trial, by various easy devices, such as putting on a green train-crew, delaying the trial train unduly so as to give it the benefit of abnormal crowds at the stations, etc. Nevertheless, the Public Service Commission after a hearing decided to order the general introduction of additional doors. Thereupon the Interborough Rapid Transit Co. made a request for permission to try another style of multi-door car, namely, a car with a door in the middle of the side, besides the existing end doors (one door at each end of the side). This request was granted, although prior to this the center door had been declared most objectionable, because some of the station platforms are located on sharp curves. A train of center-side-door cars was built, and was put into trial service last week. Its operation differs in one important point from that of the Arnold style of car; the latter was planned for absolute separation of leaving and entering passengers, one door being restricted to use as exit, the other as entrance, while the center-side-door car is run with all three doors in service as both entrance and exit.

Another peculiar feature of the rapid-transit situation in New York is that the Interborough company has recently placed large advertisements in the daily newspapers, under such captions as "What Chokes the Subway." The burden of the advertisements is the plea that they should be authorized to build additional subway lines and a third track on one of the elevated lines. The last-named demand has been made repeatedly ever since the consolidation of the elevated railways (Manhattan Ry. Co.) with the Interborough company, which originally operated the subway only. The demand has regularly been refused, and there is strong opposition to it. A proposal for a parallel subway on the part of another company than the Interborough has been before the Public Service Commission for some time.

HIGH WATER IN LAKE CHAMPLAIN interrupted traffic on the Rutland Ry. embankment through the lake between Colchester and South Hero, Vt., on April 22. The Rutland runs north through the lake, by way of Grand Isle, the water stretches being crossed by rock and earth embankments. The washout affected the southerly one of these lake crossings. The lake is reported to have reached close to the highest level previously known. Heavy snowfall last winter in Vermont and the Adirondack region has been melting rapidly in the past month.

A 12-MONTH TEST OF A BITUMINOUS GAS PRODUCER was completed April 3 by the Westinghouse Machine Co., which shows a very good efficiency combined with remarkable tar prevention. The test was conducted with a 175-HP. producer and gas engine. The period of twelve months was devoted to tests of from one to four weeks' duration with the producer in operation both 10 and 24 hours per day. The fuels tried included Pittsburg slack and run-of-mine, lignites from Texas, South America and northern Colorado, peat and other fuels from various parts of the country. In most of the tests, the load on the equipment was maintained at full rating. One special test, however, of 1½ months' duration, was made with the producer standing idle to determine accurately the stand-by loss.

The drawing of the fires after one year of continuous operation was made the occasion of a demonstration before government officials and engineers interested in bituminous gas practice. Although the producer had just been running for one month at full load on Pittsburg coal, there was no trouble in drawing the fire, for the reason that large clinker formations were entirely absent. The producer lining was found intact and apparently in condition for indefinitely continued operation.

The most important feature demonstrated was the practically entire absence of tar in the producer gas. A detailed examination was made of the piping leading from the producer house to the engine on test and it was found that in spite of the long period of operation there were no deposits of tar or lampblack in the pipe. It is stated that this piping had not been before examined during the present test, nor for about 1½ years of previous producer experimentation. A similar examination of the mixing and inlet valves of the engine showed practically no deposits of tar or lampblack such as would interfere with its operation.

The plant tested uses no tar extractors, but is so designed that no tar is formed. After leaving the producer, the gas is simply passed through a static washer of moderate size and even the usual coke scrubber is eliminated. The gas is drawn from the fuel bed by a rotary exhauster which delivers it to the engine at a definite pressure. The regulation of the producer for load variations is entirely automatic and no gas holder is used.

The various fuels successfully gasified during the test have runs as high as 34% moisture, 35% volatile, 15% ash and 1½% sulphur. These per cents. are the maxima for the respective constituents and did not, of course, concur in any one fuel. The ash is fairly clean, analyses of occasional samples having shown that from 1% to 3% of the total combustible in the coal escapes in the ash. The gas produced has a moderate heat value and is uniform and clean. Average samples showed no more than .02 to .03 grains of impurities per cu. ft. The results of the test indicate that, with such coal as Pittsburg slack or run-of-mine, an over-all economy of 1.1 lbs. per B. HP. can be secured. This is equivalent to about 0.9 lb. per I. HP. It is stated, moreover, that the producer efficiency does not vary by more than 10% from full load to no load.

Plants of this type are already on the market, one having been in successful operation for over six months on Colorado lignite coal, and as a result of the favorable outcome of the test just completed, the Westinghouse company is making preparations for their extensive manufacture.

TEST OF A "SIROCCO" MINE FAN.—A test was recently made of the "Sirocco" mine fan installed on the No. 6 pit of the Glamorgan Coal Co. at Llwnypia. It was carried out under the personal supervision of the general manager of the company, Mr. Leonard Llewellyn, with instruments carefully calibrated for the occasion. The fan is of the double-inlet type, 11 ft. 8 ins. in diameter, and is direct coupled to a three-phase motor of the British-Thomson-Houston manufacture. The figures given represent the average of three tests:

Speed of fan and motor	183 r. p. m.
Water-gage in fan drift	6 in.
Water-gage in main drift	6 in.
Average velocity of air	1842 ft. per min.
Area of drift	184.6 sq. ft.
Volume of air	340,033 cu. ft. per minute.
HP. input at motor	420
Efficiency of motor	93 per cent.
Brake HP. on fan-shaft	390
Indicated HP. in air	321.5
Mechanical efficiency of fan	82.43 per cent.
Combined mechanical efficiency of fan and motor	76.6 per cent.

It is worthy of notice that the fan was capable of maintaining the water-gage in the drift when running at the low peripheral speed of 6,705 ft. per min.—"Engineering," London, April 16.

THE FOREIGN TRADE of the four principal Atlantic seaports in 1906 and 1907 is summarized as follows by the "Philadelphia Record":

Exports—	1906.	1907.
New York	$617,136,314	$627,949,857
Boston	98,739,647	100,872,147
Philadelphia	82,564,389	94,832,480
Baltimore	109,925,946	104,898,952
Imports—	**1906.**	**1907.**
New York	$734,350,823	$853,696,952
Boston	106,422,077	124,432,977
Philadelphia	70,801,273	79,869,942
Baltimore	30,084,053	37,774,305

THE CAYUGA AND SENECA CANAL IMPROVEMENT, noted in our issue of April 22, p. 446, is to be submitted to the people of New York for approval at the general election next November, according to the provisions of a bill which passed the legislature of New York during the session just closed. The bill provides for the issuance of seven million dollars of bonds, in partial issues as the money shall be needed, such bonds to bear an annual interest of 3%, and to be repaid in 50 years. The interest and sinking fund are to be paid by a direct assessment on the real and personal property in the State, at an annual rate of 0.001 mills on each dollar of assessed valuation. If the bill is approved at the referendum next November, the State Engineer is instructed to commence operations on the canal, which is designed to be a branch of the Barge Canal, and follows the latter closely in its style of construction.

THE NATIONAL GOOD ROADS CONGRESS will hold its second annual convention May 18-21 at Johns Hopkins University, Baltimore, Md., and May 22 at the New Willard Hotel, Washington, D. C.

Personals.

Mr. John A. Ockerson, M. Am. Soc. C. E., has been appointed Consulting Engineer of the East Side Levee and Sanitary District of St. Louis, Mo.

Mr. Wm. A. Aycrigg, M. Am. Soc. C. E., has been appointed City Engineer of Omaha, Neb., to fill the vacancy caused by the death of Andrew Rosewater.

Mr. John J. Harman, Jun. Am. Soc. M. E., has become a member of the Harman Engineering Co., civil and mechanical engineers, 129 Fredonia Ave., Peoria, Ill.

Mr. L. C. Boyd, Vice-President for the last four years of the Indianapolis Water Co., has been made President to succeed Frederic A. W. Davis, whose death was announced in this column April 15.

Mr. Carl S. Dow, Assoc. Am. Soc. M. E., until recently Manager of Publicity of the B. F. Sturtevant Co., has joined the staff of Mr. Walter B. Snow, M. Am. Soc. M. E., in Boston, Mass.

Mr. Edmund Lang, Assoc. Am. Inst. E. E., Manager of the Universal Engineering Co., of New York City, has left that position to take charge of the repair shop of the Crocker-Wheeler Co., at Ampere, N. J.

Mr. Charles L. Harrison, M. Am. Soc. C. E., formerly Principal Assistant Engineer of the Pennsylvania, New York & Long Island R. R., has been appointed Deputy Chief Engineer of the Board of Water Supply of New York City.

Mr. R. A. McClanathan, for a number of years Assistant City Engineer of Niagara Falls, N. Y., has been appointed City Engineer to succeed Mr. W. D. Robbins, who retired May 1 to become Engineer for the Board of Water Commissioners.

Mr. L. B. Merriam, M. Can. Soc. C. E., has retired from the position of Division Engineer of the Grand Trunk Pacific Ry. in charge of construction at Winnipeg, Man., and that position has been abolished. Mr. Merriam's present address is 220 Chestnut St., Winnipeg, Man.

Mr. Henry S. Wood, M. Am. Soc. C. E. and M. Am. Soc. M. E., resigned May 1 as Eastern Agent of the North American Dredging Co. and will open an office as a consulting engineer in Room 1825, Park Row Bldg., New York City. He will give special attention to dredges, dredging and reclamation of land.

Mr. C. L. Harris, Superintendent of the Southern Ry. at Knoxville, Tenn., has been appointed General Superintendent of the St. Louis-Louisville lines of that railway, with headquarters at St. Louis, Mo. The jurisdictions of Mr. Alexander Stewart, General Superintendent of Motive Power, Mr. D. W. Lum, Chief Engineer Maintenance of Way and Mr. G. W. Taylor, General Superintendent of Transportation, have been extended over the St. Louis-Louisville lines.

Obituary.

Thomas Thompson, President of the Thompson Bridge Co., of San Francisco, Cal., died at his home in that city April 22 after an illness of several weeks. Mr. Thompson was born in Scotland about 60 years ago and came to this country in 1867. He was a brother of Mr. James M. Thompson, who was recently shot by robbers as noted in this column April 22.

Theodore Minot Clark, Professor of Building and Architecture in charge of the Department of Architecture from 1881 to '88, at the Massachusetts Institute of Technology, died at his home in Boston, Mass., April 30. Mr. Clark was born at Boston in 1845 and was a graduate of Harvard University in the class of 1866. He was a Fellow of the Society of Arts, of London, and of the American Institute of Architects.

Thomas Clarkson Lovell, Superintendent of the City Water-Works of Fitchburg, Mass., for more than 34 years, died April 22 at his home in that city. Mr. Lovell was born at West Boylston, Mass., in 1846 and studied civil engineering with Phineas Ball, a civil engineer and architect of Worcester, Mass. In 1869 Mr.